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## ABSTRACT

The BrainLink project offers educational materials that focus on current neuroscience issues with the goal of promoting a deeper understanding of how the nervous system works and why the brain makes each individual special while conveying the excitement of "doing science" among upper elementary and middle school students. Project materials engage students and their families in neuroscience issues as they learn fundamental physical and neuroscience concepts and acquire problem-solving and decision making skills. Each BrainLink unit targets a major neuroscience topic and consists of a colorful science Adventures storybook, a comprehensive Teacher's Guide to hands-on activities in science and mathematics, a Reading Link language arts supplement, and a fun and informative Explorations mini-magazine for students to use with their families at home or in the classroom. This issue examines the motor system including reflexes, movement, and coordination. (ASK)

# Trouble at Tsavo: The Tale of the Black Rhino.

## BrainLink: Motor Highways.

By Grace Boyle

Illustrated by T. Lewis

Revised by Barbara Tharp and Judith Dresden

Science notations by Nancy Moreno

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BrainLink  
MOTOR HIGHWAYS

# TROUBLE

THE TALE OF



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Written by Grace Boyle  
Illustrated by T Lewis

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# ATTSAYO

PLORERS

THE BLACK RHINO



4  
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### Trouble at Tsavo *Motor Highways*



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# TROUBLE AT

## The NeuroExplor in The Tale of The Black

By  
Grace Boyle

Illustrated By  
T Lewis

Revised by Barbara Tharp, M.S., and Judith

Science notations by Nancy More

Baylor College of Medicine



Houston

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**TSAVO**

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**k Rhinos**

ith Dresden, M.S.

eno, Ph.D.

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## The NeuroExp The Beginning

All Josh Kavil saw was the stop sign. The waking up in the hospital. He had been riding was struck by a car. His skull was fractured, a

Some good came of Josh's unfortunate a learned never to ride without a helmet. Sec beginning of the NeuroExplorers.

When Josh's friends came to visit him at some of them became fascinated with the field they met a neurosurgeon, a neurosurgical neuroradiologist. These were medical specialists problems involving the brain or other parts of

It was Kyle Christian's idea to form the club to know more about the nervous system. They liked to solve puzzles and riddles and had an interest in investigating some of the mysteries of science.

Since they formed the club, the NeuroExpl have volunteered at a center for the rehabilitation of brain injury patients, held a Neuro-Science and spent a day in the hospital on rounds with a neurologist. They have learned a lot about how the brain and nervous system work, and they always are looking for exciting things to do in neuroscience.

## plorers ing

next thing he remembered was  
g his bicycle without a helmet and  
and his brain was badly damaged.  
accident. For one thing, he  
ond, his misfortune was the

Worthington Regional Hospital,  
ld of neuroscience. On their visits,  
rse, a neurologist and a  
ists helping patients who had  
of the nervous system.  
ub. The members all wanted to  
also

s of  
plorers  
tation  
e Fair  
ith a  
ow  
y  
with

*Neuroscientists study the brain and the rest of the nervous system. The basic building block of the nervous system is the nerve cell, or neuron. The word "neuron" comes from the Greek word for "nerve." How many words can you find that start with "neuro-?"*





## The Club Members

### Kyle Christian

Kyle's father is an archaeologist and often is away on digs. Last summer, he took him on a short dig in Belize. Kyle does things with the NeuroE team, and the members feel that she is a great help. Kyle likes to read science fiction books and play video games. His hobby is memorizing facts.



### The Brain

When Antonio Velasquez-Ruiz was a toddler, he was very quiet and didn't speak. Then he suddenly began speaking in full sentences. Now, he has been known as the "brain" of the team. His trouble is, only his best friend knows what he's thinking. He uses big words and long sentences. His most-used books are a variety of encyclopedias, and Gray's Anatomy.



### Max Miller

Max has been friends with Tessa since they were babies, and that's why he and Tessa spend most of their time together. Max reads, Max often works on projects, or builds things with wood. Max is studying neurology when his grandfather died of memory loss and was diagnosed with Alzheimer's.

gist at Dargate University  
st year, he took Kyle with  
Kelly, Kyle's sister, sometimes  
explorers, although some of  
little young for the club.  
on books and play computer  
zing fascinating trivia.

z, alias The Brain, was a  
d never tried to talk. One day  
n complete sentences. Since  
he smartest boy in town. The  
can understand The Brain's  
. The Brain reads a lot, but  
y fat dictionary, a set of  
atomy.

he Brain since they were  
derstands him so well. They  
ether. While The Brain  
models of boats and planes  
Max became interested in  
her had trouble with his  
with Alzheimer's disease.



### **Lakeisha Crawford**

Lakeisha wants to be a chess player. She has a pocket chess game around with her. She is interested about things in terms of chess. She has developed a good memory for chess games and sports. Karate is another thing Lakeisha has a little sister



### **Isley I and Isley II**

Identical twins, Isley I and Isley II call them by their actual first names. They both love baseball and basketball. Isley I and Isley II and has a 1954 Mickey Mouse car. Isley II holds the record for corn throwing in his school. They are both interested in science and have notes of Charles Darwin.



### **B.J. Armstrong**

B.J. spends a lot of time with her drumsticks with her. She carries her drumsticks with her. She likes a hard surface she can find! She likes to be a doctor but she also wants to be a nurse. She has two brothers who sometimes are in the NeuroExplorers. One brother is in medical school. Her brother's formal name, Beverly Jane B.J., and so do her friends.

ess grandmaster, so she carries  
nd with her. She often thinks  
hess problems, and she has  
y. She also likes to play other  
lessons are her latest passion.  
who has epilepsy.

d II (even their parents don't  
first names) are always kidding  
e sports and play soccer,  
sley I collects baseball cards  
Mantle in good condition. Isley  
nsecutive basketball free  
r father, a bird-watcher, got  
by reading to them from the

ith her drums. In fact, she  
n her and uses them on any  
She wants to play in a band,  
physician. B.J. has two older  
ct as advisors to the  
her is a neurologist at a  
ers never liked to use her  
, so they've always called her

# TROUBLE AT



## Tennis Anyone?

The NeuroExplorers watched Shiloh Nimbus smashes and perfectly placed shots left them gasping. Back and forth the ball of the points were won by Shiloh. Her opponent Nimbus was one of the best tennis players Kyle B.J. and the Isley twins had ever seen. The game a few minutes, the NeuroExplorers didn't even not

# TSAVO



s play tennis. Her overhead  
sping with wonder and  
went over the net, and most  
it was good too, but Shiloh  
, Lakeisha, Max, The Brain,  
e was so intense that, after a  
vice the players' wheelchairs.



## A Call To Order

Later, back at Kyle Christian's house, The Brain looked on his face. "I apologize for the cacophony,"

Shiloh looked at him blankly. Although she was a star in her class and prided herself on her vocabulary, she was. Fortunately, Max was standing over her shoulder.

"He's sorry there's so much noise in here, but don't worry about The Brain. You'll get used to his noise. He just likes to use big words, that's all."

Shiloh nodded. She might have spoken if she had been heard.

It was always noisy just before a NeuroExam, especially one in Kyle's basement. The drums came to her headphones, drumsticks flailing, knocking over a chair. Periodic crashes shook the floor—Lakeisha was fiddling with an old TV in the corner, which contributed to the noise, trying to tell Shiloh about their last great adventure—their search for the skull in the Caves at Calicoon.

Finally, The Brain couldn't take any more. "Too much clamor?" he asked. Nobody noticed. The Brain spoke slightly louder. "We cannot commence until the Brain is heard."

Still no response. Max was getting ready to speak.

"Quiet!!" The Brain shouted, instantly freezing everyone.

"No need to translate that," Max said with a smile.

er

Brain had an annoyed look  
he said to Shiloh.  
e was one of the top students  
lary, she was baffled.  
lder.

"Max said to Shiloh. "Don't  
m. He's really a nice fellow. He

she thought she would have

explorers' Club meeting,  
ning sound was B.J., attached  
king out a rhythm on the back  
the Isleys were wrestling.  
back of the room. Even Kyle  
about the NeuroExplorers'  
ll of the Mishigara Man in the

"Could we restrain the  
n cleared his throat and spoke  
is riot is subdued," he said.  
o help.  
eizing the NeuroExplorers.  
smile. "Let's start the meeting."



### **A New NeuroExp**

The meeting was going well. Although the NeuroExplorers had one exciting piece of bus Shiloh Nimbus, was becoming a member. Sitting NeuroExplorers wanted to ask Shiloh some q hard to find the words.



plorer

y had no big projects, the  
iness. Their new friend,  
ing around the basement, the  
uestions, but they found it



Shiloh sensed  
probably wondering  
wheelchair," she

The NeuroE

"I don't mind

Shiloh continued

"I heard it was

Isley I.

"I heard it was

"A gunshot?

"I thought you

Lakeisha added

Shiloh laughed

rumors—but I don't

many different

"I think most

because you were

Kyle said, "and, well, everybody noticed you..."

Shiloh nodded her head. "Yes, I know," she

just moved back to the United States from Kenya

"Kenya?" Lakeisha interrupted. "Africa? What  
Africa?"

My father is a zoologist who specializes in  
worked for the Kenyan government in one of the  
years," Shiloh answered.

B.J. looked confused. "Large, exotic animals

d their curiosity. "You're  
ering why I need to use a  
e said.

xplorers remained silent.  
d talking about it, really,"  
d.

was a diving accident," said

as a car accident," said Isley II.

" B.J. asked.

ou were born that way,"

ed, "I knew there were  
didn't know there were so  
ones!"

st of the rumors started  
re new in school this year,"  
and..."

e said. "Anyway, my family  
ya...."

Wow! Why were you in

large, exotic animals. He  
their game parks for twelve

ls?" she said aloud.

"Right," Shiloh said, "like elephants, giraffes, and one type of rhinoceros that Dad is especially interested in."

"The black rhinoceros!" The Brain repeated. "A majestic creature, hunted almost to extinction."

"That's right," Shiloh said, "and the black rhinoceros has special meaning to me. It's because of the black rhinoceros."

The NeuroExplorers sat in tense silence, watching the frightening pictures of huge, angry rhinos, and wondering through their brains as they gathered courage. What terrible thing had happened to Shiloh's black rhinoceros involved?

*When we move, muscles and the nervous system must work together.*

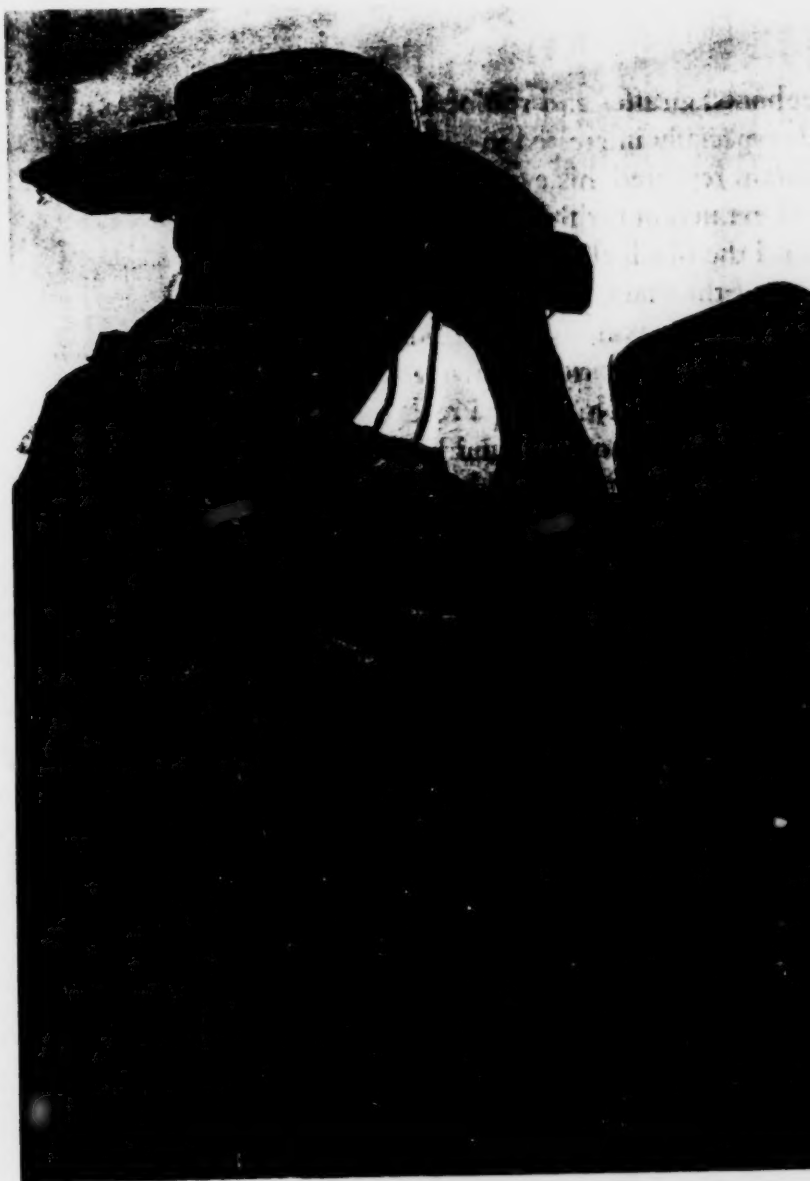
*Signals for movement start in the brain or spinal cord. The messages are carried along special cells, called neurons, to the muscles. When the spinal cord or other parts of the nervous system are damaged, messages can't get through.*



...fes and rhinoceroses. There is  
...interested in—the black rhino.”  
...ed, his eyes flashing delight. “A  
...for the harvest of its horn.”  
...k rhino always will have  
...ck rhino that I’m paralyzed.”  
...waiting for Shiloh to continue.  
...nd who knows what else, ran  
...e to hear the rest of the story.  
...Nimbus? And how was the









## Poachers at Tsavo

Shiloh began to tell her story. "My father went on some of his expeditions near our home in Kenya to get supplies and set off in the jeep to track the animals."

"Did you hunt them?" Isley I asked.

"Oh no!" Shiloh said. "We tagged and followed their habits and helped them if they were sick. Hunted against the law, and besides, my father loves those animals. He takes care of them. He would never hurt them."

"We've heard stories of people hunting the big animals, even in the game preserves," Isley II added.

"That does happen," Shiloh said, "but the hunters are poaching—killing the animals illegally—and the black rhino is one of their most treasured finds. That's what set my father and me on this expedition onto the plains of Tsavo."\*

The NeuroExplorers couldn't wait to hear more! As Shiloh began to tell about her fateful day on the Tsavo plains, the NeuroExplorers felt as if they were there.

\* pronounced SAH-voh

Shiloh  
anima  
kinds



biolog  
the ne  
messa  
What

vo

would take me with him on  
ya. We'd pack our tent and  
imals."

owed them, studied their  
ting in the preserve is against

's father is a zoologist—a biologist who studies  
ls. Biologists look for answers to many different  
of questions about organisms. Shiloh's father, for



example, is  
interested in  
learning about how  
rhinos live in their  
natural  
environments.

Other biologists  
study things that  
can be seen only  
with a microscope  
or that happen  
inside cells.

Neuroscientists are

ists who are especially interested in all aspects of  
nervous system—for example, how nerve cells carry  
ages and how the brain processes information.  
other kinds of biologists can you think of?

## Trek to Moldavvi Pass

Gently, gently the wind blew as it flowed on. There was nothing but peace in the sun and clouds. A stampede of large animals was storming toward Shiloh, not even noticing her in their path.

A voice broke through her terror. "Shiloh!" it said. Shiloh, breathing hard, opened her eyes. A hand shook her shoulder. The stampede had been a dream, and began to come back to the real world.

"You're a heavy sleeper," her father said, shaking his head, trying to leave the rhinos behind and forget about her.

Dr. Nimbus turned away from the sleepy girl. "The jeep is loaded. I'd like to be in Moldavvi Pass," he said.

"Is that where they spotted the skeletons?"

"Yes," said her Dad. "Maybe we can pick up some bones. The government wants me to study the remains of the poachers. I can learn about the poachers."

"Poachers—," Shiloh exclaimed, "I hope we can catch them."

"Don't say that, Shiloh," her father said. "We need to go with a squad of armed poachers!"

The ride to Moldavvi Pass was never boring. The landscape was grasses, patches of shrubs and low trees, Shiloh saw many animals. With her trusty binoculars, she searched for poachers. She wanted to become expert at recognizing all the

Pass

ver the calm African plain.  
oudless sky. Suddenly, a herd  
threatening to run over her,

Come on, Shiloh, wake up,"  
s with a start as her father  
dream. She exhaled slowly

smiling. Shiloh shook her  
cus on the man in front of

irl. "Let's go, Shiloh," he  
ldavvi by nine."

Shiloh asked.  
up some clues there. The  
the dead rhinos to see what I

ve find them!"  
We aren't equipped to deal

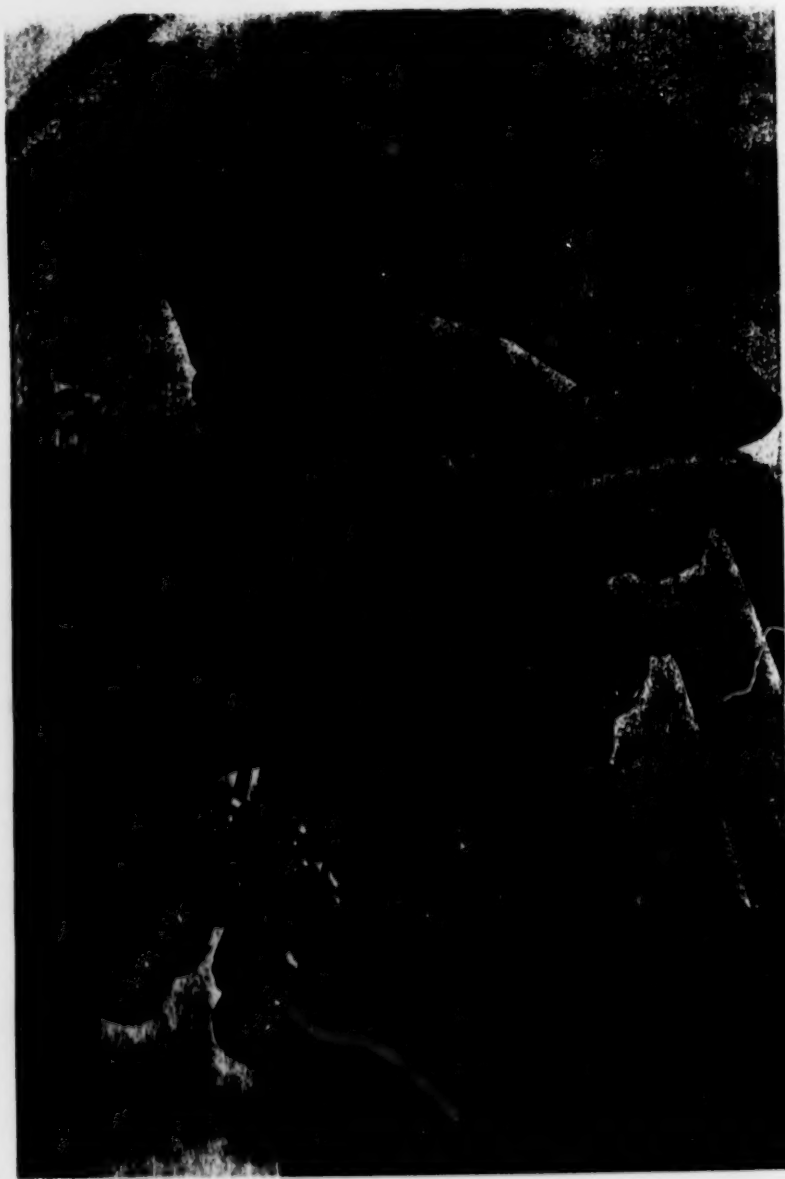
g. Through low brush and  
h watched for the great  
ned the sky for birds. She  
e different kinds.





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Shiloh turned around and stood in her seat, holding on to the roll bar of the jeep while they drove. She aimed her binoculars at the sky and amazed her father with her growing ability to identify the African birds.

"Shiloh, I think you'd better sit down," her father said as the jeep swerved and plunged through some underbrush. "And be sure to fasten your seat belt," he added firmly.

"Oh Dad, come on," Shiloh called back. "You're talking to the girl who took first in the balance beam, remember? I won't fall." But her father's stern look made her give in.

## A Spinal Cord Puzzle

"You were a gymnast?" said a surprised Isley I.

His outburst broke the spell of Shiloh's story. The NeuroExplorers back from Africa. Max was far from used to the oppressive African heat. B.J. blinked, her eyes averted from the Kenyan sun. The moment was undone.

"Isley, don't interrupt!" Kyle said.

"No problem," Shiloh replied. "Yes, I was p... beam and parallel bars. I'm still crazy about sports. You surprised that I can play tennis?"

The NeuroExplorers looked at each other, and Isley I finally said, "Well, I guess we were just amazed that a wheelchair could get around the court and smash a ball."

"The problem is just in my legs," Shiloh said. "I'm paraplegic—my injury involves only my lower body. I can do with my arms and upper body, and my wheelchair goes around the tennis court really well."

The Brain stood up and began to pace. "This is a neurological puzzle that merits the club's attention."

"I don't get it, Brain," said Isley I.

"That's no big surprise," said Isley I, shoving Isley II.

"Hold on, Isleys," Max said. "The Brain made an interesting neuroscience question here for us to solve."

zle

y II.

y and transported the  
nning himself to fend off the  
ching from the strong

pretty good on the balance  
orts," she continued. "Are

nsure how to respond. Kyle  
that someone in a  
sh the ball that way."  
d with a half-smile. "I'm  
body. I can do anything you  
sports chair helps me move

s poses a fascinating  
ttention," he said.

g his brother.  
ans that there's an  
think about."

"We know that paraplegia means you're  
The Brain said.

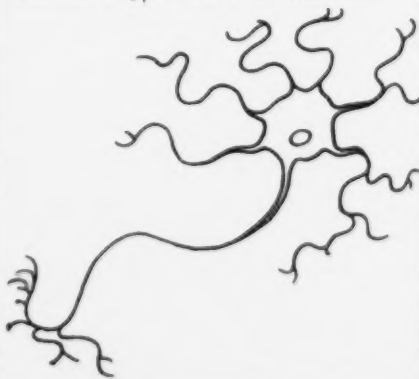
B.J. was catching on. "And quadriplegia in-  
move anything from the neck down," she added.  
brother works in a rehab center."

"And the brain doesn't have to be involved."  
The Brain continued.

*Billions of neurons are linked  
together to form the brain, the  
spinal cord and the rest of the  
nervous system. Neurons carry  
messages along long tails, or  
nerve fibers, called axons.*

*There are more than 10,000  
kinds of neurons in our bodies.*

*This is a typical motor neuron.*



"The question is  
between paraplegia  
said together.

The Isleys sat in  
head. B.J. tapped on  
the answer. Kyle and  
Shiloh Nimbus was

"You've gotten r  
to her new friends.  
usually are caused b  
the brain. The differ  
where the spinal cor  
cord at a high level,  
become quadriplegia  
lower level, you can

paralyzed below the waist,"  
involves more paralysis—you can't  
ed. "I know that because my  
in either of those conditions,"  
what causes the difference  
and quadriplegia?" The Isleys  
silence. Max was scratching his  
n the table, trying to drum up  
d Lakeisha seemed stumped.  
smiling.  
ight to the point," Shiloh said  
"Paraplegia and quadriplegia  
by injury to the spinal cord, not  
rence between them is the place  
rd is injured. If you damage the  
near your neck, you can  
c. If the cord is injured at a  
become paraplegic."

It was as if someone had turned on the lights. "Of course!" B.J. said, striking Kyle's bicycle helmet like a cymbal. "Now I remember how it works. The orders for muscle movement start in the brain. Cells in the brain—neurons—extend all the way to the spinal cord and carry orders to other neurons that communicate with the muscles."

Everyone started talking at once, trying to explain the spinal cord to each other, and to themselves.

B.J. tapped out her thoughts as she spoke. The Brain paced, talking to no one. Lakeisha and Kyle ran back and forth between models and charts. Excitement was in the air. Nimbus sat quietly, smiling. She had found so

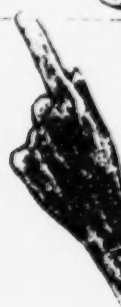




the air. Through it all, Shiloh  
me great new kids for friends!



# THE HUMAN SPINE



## A Good Question



Max finally got everyone quiet again and into their seats. Standing by a poster of the spine, Max and The Brain excitedly explained that the spinal cord lies within the protective bony column. "All along the spinal column, motor neurons go out from the spinal cord, carrying messages for movement to the rest of the body," Max said.

Lakeisha frowned. "But there's something I still don't get," she said.

"I'm afraid I am unable to comprehend your perplexity," The Brain said to Lakeisha.

Everyone looked at Max. "He wants to know why you're confused," Max interpreted.



"Well, if you break your  
you get a cold, it goes away,  
better after a while."

The Brain nodded and said  
Lakeisha. What you want to  
permanent?"

"Right," Lakeisha said. "I  
have to stay paralyzed?"

The NeuroExplorers didn't

"The spinal cord doesn't  
system tissue doesn't repair  
cord injuries usually are per

"But I read that there are  
injuries," Isley I said.



*Neurons communicate with each other by sending special chemical messengers across tiny gaps between cells. The gaps are called synapses.*

*Motor neurons carry messages from the brain or spinal cord to muscles. Sensory neurons carry information back to the spinal cord and brain.*

arm, the doctor puts it in a cast and it heals. If  
When you cut yourself or pull a muscle, it gets

id, "I underestimated your consternation,  
know is, why are injuries to the spinal cord

"I mean, why doesn't it get better? Why do you

n't know the answer. They looked to Shiloh.  
heal well," she said softly. "Most nervous  
itself like skin and bones do. Brain and spinal  
manent."

e new medicines to treat spine and brain

"Yes," said Shiloh, "they help keep down swelling and it's given soon enough. But t

The NeuroExplorers were that kept them wondering—Kenya—a massive shape the scientists. A black rhino.

It was then that Shiloh c

T

White bones...surround by hyenas and vultures. Sh unyielding Kenyan sun. Lar feet. She knew from her fat of a black rhino.

"How do you know thi

"The shape of the crani skull. "It looks like a rhino because the skull is narrow rhino. Black rhinos' jaws a and twigs from the trees fo jaws are wider, almost like

"But where are the horn them," Shiloh said. "I thou

e's a new medication, a kind of steroid, that can  
d inflammation and limit the amount of injury, if  
there really isn't any way to repair the damage."  
re silent for a few seconds. There was something  
—something about Shiloh's paralysis, her life in  
at wandered mysteriously among the young

decided to continue her story.

## **he Black Rhinoceros**

ed by buzzing flies, picked clean and scattered  
loh raised her arm, trying to deflect the  
ge sun-bleached bones lay in the grass at her  
her's expression that they had found the remains

s is a black rhino, Dad?" she asked.

um," her father said, handling the long, irregular  
, and it's pretty safe to say it's a black rhino,  
er and more pointed than in its cousin, the white  
re more pointed, too. They have to pull leaves  
r food. White rhinos eat short grasses, so their  
a lawnmower."

as? I don't even see a place in the skull for  
ght black rhinos had two horns."







"That's right. But they aren't," he said. "They're made of dense metal. Unfortunately, they're very valuable. People kill these animals—for poachers. They kill the animal and take the carcass. They don't use the meat. They're so angry! They could just send the carcass away, if they have to have them grow back." Shiloh's father shouted to the sky, "The black senseless poachers!"

"Why do they want the horns?"

"They sell them to people who use them for a special kind of dagger handle, which they think is a potent charm for money for it," her father answered.

"Is it a good medicine?" Shiloh asked.

"No, but that doesn't matter. If they have it, the poachers will hunt the animal."

Shiloh looked over the scene at the hot iron. As she looked at the scene, her father said to her, "Do you think we can do anything?"

"We aren't the police, Shiloh," her father said. "We can't arrest and identify. But we'll stay for the evidence, or maybe find a live animal."

aren't true horns, made of bone," Dr. Nimbus  
by compacted hair-like fibers and,  
valuable to some people. That's the only reason  
for their horns. This definitely is the work of  
a poacher and then remove the horns and leave the  
meat or the hide—just the horns. It makes me  
hate the animal and cut the horns off with a  
machete. Then the rhino could live, and his horns  
wouldn't grow more and more angry as he  
thinks the rhino is almost extinct because of these

"Horns so much, Dad?" Shiloh asked.  
"In other countries. Some people use the horns  
to make a handle. Others grind the horn into a powder  
for medicine, and people are willing to pay a lot  
for it," he answered.

"Shiloh asked.  
"Yes," he said. "If someone is willing to pay for  
the rhino anyway."

"One day, the sun pushing down on her neck like a  
skeletal remains, she became as angry as her  
father. "Get these poachers, Dad?" she asked.  
"No," her father said. "We're just here to track  
the rhino for a day or so and see if we can turn up some  
rhino that needs tagging or medical help."

### Caught by Surp

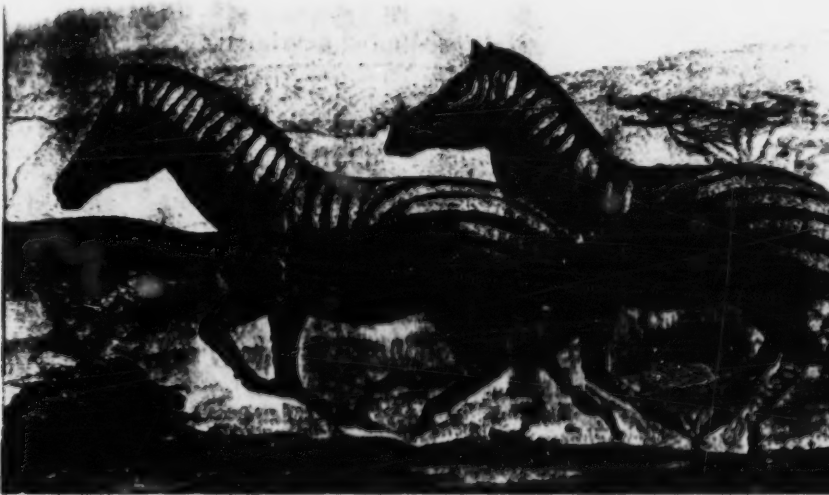
The jeep rolled slowly through the low grass. Nimbus thought there might be a rhinoceros. Droppings and newly crushed branches told he had been here not long ago.

"Shhh," Dr. Nimbus whispered.

"What, Dad?" Shiloh whispered back.

"There," he said, pointing out toward the horizon.

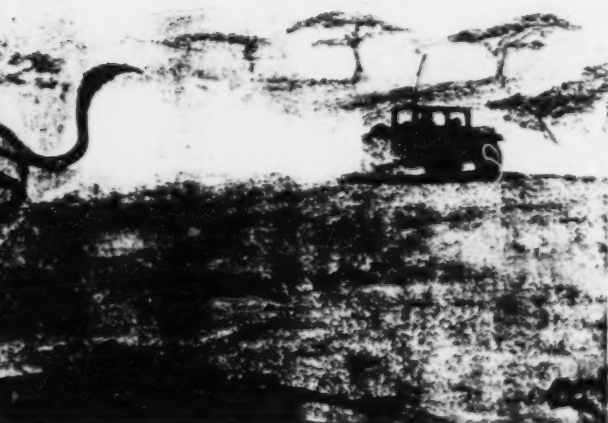
Shiloh strained but couldn't see anything. "Where?" she asked.



rise

asses and small trees. Dr.  
nearby. Fresh tracks,  
him that a large animal had

horizon.  
except the Kenyan terrain.





57

20

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58

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"That slope beyond the last group of trees is the jeep, and they quietly stepped out.

Shiloh saw the slope and let her eyes trip the bottom. There they were—three rhinos, one at a waterhole. "Wow! Let's get closer, Dad," she said.

Dr. Nimbus didn't have to answer. As if the three massive beasts lifted their heads together and began to move...and then they started to charge.

Shiloh and Dr. Nimbus stood as still as the trees. It was a moment before they grasped what was happening.

"Dad," Shiloh gasped, "Are they..."

"They're charging us!" Dr. Nimbus screamed, throwing the arm and running for the jeep.

What they didn't see, in the dust behind them, was the three rhinos chasing the huge beasts toward a snare—and Shiloh!



s." As he answered, he stopped

down the grassy knoll to the  
larger than the others, sharing  
he whispered.

they had heard Shiloh's plea,  
together. They leaned forward  
to run.

the acacia tree next to them. It  
was happening.

med, grabbing his daughter by

the rhinos, were poachers,  
directly toward Dr. Nimbus





## On Top of the

A sudden crash broke the magic web of Isley I was on the floor. He had fallen off his

"Isley I," Max said, running over to help

"He's running from the rhinos," Isley II

It was almost true. Shiloh's story was so had felt a surge of fear as she described the animals and poachers.

"You should be on television, telling stories."  
"You do it so well!"

"Or write a story about your adventures,"

all agreed.

Lake

"It's kind of you're so though..

"She' from the NeuroEx their sho in the co the brain

"Hey mirror, n laughed.

*The motor cortex is a special part of the brain that directs movements that you choose to make. This includes things like raising your hand in class or trying out a new dance step.*

*The cerebellum at the back of the brain stores motor programs for movements that you have learned, like walking or throwing a ball.*



## Brain

Shiloh's story. Max jumped up.  
s stool.  
o him, "what's the matter?"  
said matter-of-factly.  
real that the NeuroExplorers all  
double threat of charging

ries," Lakeisha said to Shiloh.

B.J. added. The NeuroExplorers  
l.

isha looked intently at Shiloh.  
d of amazing," she said, "that  
o good at so many things, even  
."

s not disabled *here*," a voice  
e corner interrupted. The  
explorers all turned to look over  
oulders. The Brain was standing  
corner, studying Kyle's model of  
n.

, Brain, it's like looking in a  
ight?" Isley II said. Everyone

As The Brain continued to think, he ran his finger over the top of the brain.

"What are you doing, Brain?" Lakeisha asked.

"Studying the motor cortex," The Brain answered. "That's where the impulses for movement begin. When we think about moving our hands or feet, the impulse to carry out that action starts right here," The Brain said, pointing, "in this strip on the top of the brain."

"That's the strip of the brain right under where you wear headphones!" said B.J., holding up the headphones to her cassette player. She placed them over the model.

"Right," Shiloh answered, eager to be a part of the brainstorming, "and different parts of the motor cortex have special functions. One controls your ankle, and one controls your face, and fingers and hands."





ons. Like one part controls  
there's another part for your

The NeuroExplorers all nodded, but the Shiloh's tale. They knew that, somewhere and the pursuit of the poachers, lay the answer to the injury.

### Rumbling Thunder

Dr. Nimbus knew two things very well—fast! The average male rhino weighs around 7,000 pounds and can run 25 miles per hour. If you get in the way of a charging rhino, you'll be run over by a car.

Father and daughter jumped quickly into the truck, started the engine and turned the wheel hard, ramming through the tall dried grass, the shoots cracking like brittle sticks under their wheels. Beyond the dust raised by the rhinos, the sound of the running feet of men who were chasing them.

Dr. Nimbus floored the gas and drove around a sharp turn, and the animals followed them.

"Shiloh," he yelled above the roaring noise of the engine. "Give them our position. Tell the rangers. Give them our position. Tell the rangers."

Snatching the handset off the dash, Shiloh dialed the number for the ranger station. "Shiloh Nimbus calling from Mole Creek. We're being chased by poachers. Chasing us! Send help!"

Shiloh got no further. Breaking out of the brush, Dr. Nimbus slammed on the brakes and stopped. Two poachers had popped up in front of the truck.

"Dad!" Shiloh screamed. One of the poachers was holding a bow and arrow. The other had a bow and arrow slung low by his side.

y were eager to hear the rest of  
among the charge of the rhinos  
wer to the mystery of Shiloh's

## nder

-rhinos are very big and very  
d 4,500 pounds and can run 25  
charging rhino, it's like getting

the jeep. Dr. Nimbus gunned the  
the vehicle through a patch of  
le glass as the jeep tore through  
they could see the glint of a gun  
ng the animals. The poachers!  
way from the rhinos. He took a

ise, "get on the radio and call  
em we need help, fast!"  
h quickly reached the ranger  
lavvi Pass. Three rhinos spotted,  
"

ll grasses onto the wide-open  
s they held on for their lives.  
em.  
achers was pointing a rifle. The  
s side.





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“Shiloh! Down!” Dr. Nimbus hit the ga  
hurling a shower of gravel on the poachers  
sounded like a tire blowing out, but the jee

From behind, the ground shook and a r  
from the acacia scrub. Shiloh turned, her b  
jumped over mounds and crashed through  
twisted in her seat, made her heart jump. E  
a mad, frantic, roaring charge were the rhi  
pounds of terrified animal fury!



s and skidded into a tight turn,  
Shiloh heard a loud bang. It  
sped away frantically.  
rumbling thunder seemed to rise  
body jerking wildly as the jeep  
the brush. What she saw, as she  
Breaking down the vegetation in  
nos—over twelve thousand

### **Knee Jerk Reaction**

B.J. hated the thought of  
gunshots, and the only rhinos  
she had seen were standing  
quietly at the zoo. As the story  
grew more exciting, she became  
more and more tense and began  
tapping her drumsticks wildly  
on the edge of Isley I's stool.  
Tap-tappity-tap-tap....She  
missed the stool and hit his  
knee instead. Pow! Isley I's  
lower leg snapped upward,  
kicking Max on the elbow. As  
Max's arm flew up, his drink  
spilled on Shiloh.

"What's your problem?!"  
Kyle yelled at Max. He  
tossed a towel to Shiloh.

"It appears as though  
we have a causal chain of  
events precipitated by an  
involuntary reaction, the  
patellar reflex," The Brain  
stated.

"The Brain's right,"  
Max said. "That was some  
chain reaction!"

"I just hit Isley I on the  
knee by accident," B.J.  
added.

"Exactly," said The  
Brain, "and he exhibited the  
classic knee-jerk reflex. It's  
just the same as when the  
doctor taps your knee, and  
your leg jumps up

involuntarily. This involuntary movement is a  
movement, the impulse comes from the brain,  
faster, because the brain isn't involved."

"Wait a minute!" Isley II yelled. Everyone l

"He's confused," said Isley I.

"And I suppose you understand all that?"





reflex. With voluntary  
 but reflexes can happen much

looked at him.

Isley II shot back.

Reflexes happen in the twinkling of an eye, within fractions of seconds! How can we react so quickly?

Reflexes follow simple pathways. For example, if you step on a piece of glass, a reflex response is triggered in your leg. Immediately, sensory neurons in your foot send a signal to motor neurons in your spinal cord. In a flash, motor neurons carry messages to muscles, so that your foot lifts itself out of danger. Only later does your brain receive a message through the spinal cord, letting it know what happened. That's why you feel the pain after you have jumped away, and then you say, "Ouch!!"



"Sure I do," said Isley I. "Just watch." He stepped on a soda glass. "I want to pick this up. That's why my brain sent signals through my spinal cord to my muscles, and I picked up the glass. Voluntary."

"But this," said Isley I, "is involuntary." Without warning, he struck Isley II's knee with the soda glass. Isley II immediately kicked out into the air.

"Hey, cut that out!" cried Isley II.



He reached out and picked up a  
voluntary. I thought about it, and  
rd and out the nerves to my  
ry."  
movement," and, without any  
side of his hand. Isley II's leg

"See? That's your knee-jerk reflex! You ha  
brother said.

"Why?" asked Isley II.

"That's what The Brain just told us," said M  
involve the thinking part of the brain. That's w

"Right," Shiloh said. She understood all a  
back to that fateful day in Africa.

*Involuntary movements happen without our having t  
involuntary movements controlled by the brainstem  
help our bodies to function properly. Reflexes also a  
because we don't have to think about them.*

*Voluntary movements happen only when you want t  
They may be things you have never done  
before or movements you carry out  
every day, like walking or playing a  
sport. Voluntary movements improve  
when you practice them.*



and no control over it," his

Kyle. "Because reflexes don't  
why they can happen so fast."  
long. Now her mind dashed

to think about them. Some  
such as breathing and digesting,  
are involuntary movements.

them to.





## An Unexpected

Shiloh remembered it so well! Spinning father had battled the steering wheel. The seemed right behind them. More poachers armed and waiting.

Suddenly, as they reached the top of a front of them. Could they get around it? turn. There was no choice! From that moment happen instantly. There was no time to the ravine as they reached the crest.

Shiloh held on. She put her head down belt. She hadn't put it on. The jeep was in the Tsavo sky, wheels spinning madly on Shiloh's fear of the poachers and the animal she was rising, going higher, thrown upward force. Then she landed on the ground with

Suddenly a second, different thunder sound, accompanied by an intense wind. consciousness, Shiloh saw a helicopter. To her call.

## d Flight

ing, almost out of control, her  
e thunder of the charging beasts  
rs could be anywhere—hidden,

small ridge, a ravine appeared in  
There was no time to stop and  
ment on, everything seemed to  
ink or act. The jeep had to jump

a, and she saw her lap. No seat  
n the air. Soaring, flying, scaling  
air, the jeep flew above the ravine.  
als disappeared. Suddenly she felt  
ard to the sun by a powerful  
h a sickening thud.

arose. It was a deep, chopping  
In her last second of  
he rangers! They had received





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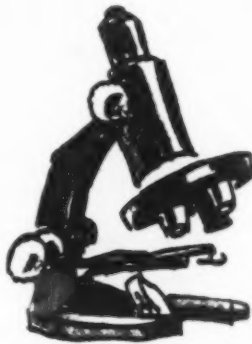
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## New Beginnin

The NeuroExplorers were exhausted. They had spent all day in the Kenyan sun—fleeing from poachers, arriving at the same final, painful escape with

"I woke up the next day in a hospital in London. The doctors there were great, and they used all the

Even ten years ago, scientists did not think that it ever would be possible to repair a damaged spinal cord. Now, researchers believe that new advances may someday help damaged nerves to regrow partially or may allow messages to be sent around areas that have been injured.



injury.  
surger  
spinal  
from h

“W  
Lakeis

“It was re-

Shiloh  
care. I

rehab  
how to

walk,  
can't o

tennis  
learn to

forward  
summer

"G

gs

felt as if they'd been struggling  
ers and stampeding rhinos—and  
Shiloh.

Nairobi," Shiloh said. "The  
ne newest treatments for spinal  
The steroids and emergency  
y to release the pressure on my  
cord probably kept the damage  
being even worse."

What a terrible experience!"

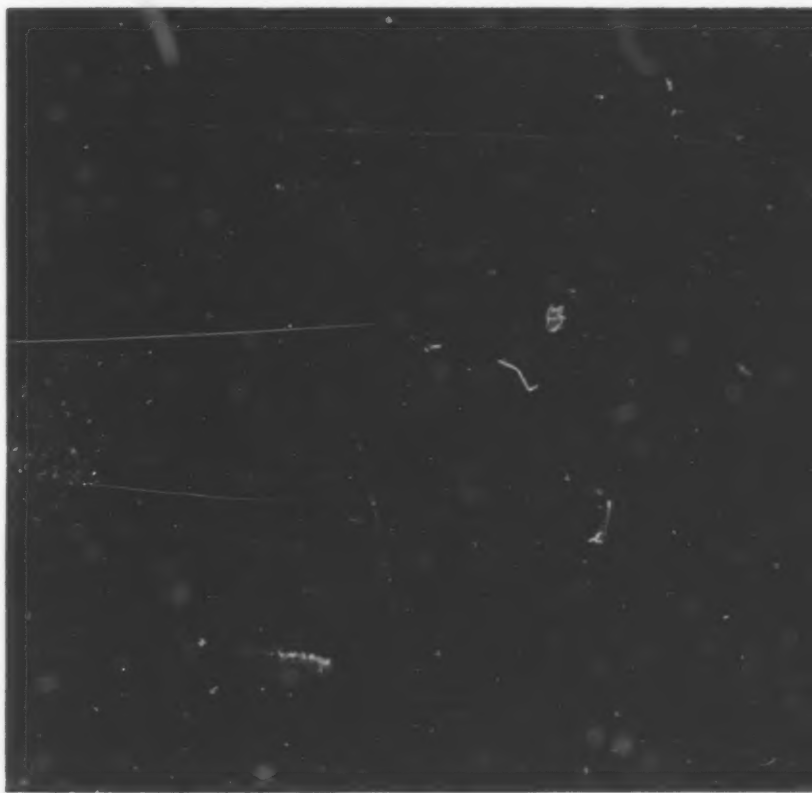
ha said, shaking her head.

was very scary, and I guess I  
ally bummed out for a while,"  
replied, "but I got really good  
had six months in a  
ilitation center, and I'm learning  
o live with my injury. I can't  
but I can get around just fine. I  
do gymnastics any more, but  
sure is fun—and I'm going to  
karate soon. I'm really looking  
ed to going back to Kenya this  
er, too!"

going back?" Kyle exclaimed.

“Dad’s going to capture a pair of black r  
Shiloh explained. “The Kenyan government  
population in a more protected environment

The NeuroExplorers just looked on in ac  
lot from Shiloh Nimbus—a lot that they wo



rhinos from the Tsavo park,"  
wants to start a new  
t."  
admiration. They had learned a  
uld never forget.





## Glossary

- acacia (uh-KAY-shuh) - a spiny tropical tree belonging to the legume family, with long, pinnate leaves and clusters of small flowers, fruits or pods
- Alzheimer's disease (ALLZ-hy-merz diz-eez) - a disease, characterized by the death of brain cells of the central nervous system so that people can no longer remember recent events
- anatomy (uh-NA-tuh-mee) - the structure (both inside and outside) of an organism
- archaeologist (ar-kee-AHL-uh-jist) - a scientist who studies the remains of ancient civilizations
- black rhinoceros (ry-NOS-er-us) - a large, powerful, scrub-dwelling rhinoceros with thick gray skin and two horns on its snout
- brain (BRAYN) - the control center of the central nervous system, located in the head and attached to the spinal cord; the command center of the body
- carcass (KAR-kus) - the dead body of an animal
- cell (SEL) - a tiny, basic structural and functional unit of an organism
- cerebrum (suh-REE-brum) - the large, rounded outer layer of the brain; where thinking started, sensory input is received, and thinking and learning take place
- cortex (KOR-tex) - the outer layer of the cerebrum
- cranium (KRAY-nee-um) - the bones of the head except for the jaw
- Darwin, Charles (DAR-win) - a naturalist in the 1800s who developed the theory of evolution; he lived in the world and is known for his book, "On the Origin of Species"
- epilepsy (EH-pih-lep-see) - a condition brought about by abnormal electrical activity in the brain that causes a person's awareness and actions, often with jerking movements, to stop for brief periods of time
- exotic (eg-ZAHT-ik) - belonging to or living in another country or culture
- extinct (ek-STINKT) - no longer existing
- extinction (ek-STINK-shun) - the condition of being extinct
- fiber (FY-ber) - a thread or threadlike part of a material

to the pea family; it produces large bean-like

found especially in older adults, that destroys  
no longer remember or think properly  
(and outside) of a person, plant or animal  
lies the remains of past human life  
sub-tree-eating mammal of Africa, having a

ous system, located within the skull and  
e body

which all living things are made  
r of the brain where voluntary movement is  
ning occur

for the jaw bone  
who studied plants and animals around the  
Species"

y sudden changes in the brain that affect a  
vements of the body and limbs, for short

part of the world

inct or the process of becoming extinct

fracture (FRAK-cher) - a break, especially of a bone  
 impulse (IM-puhls) - the transmission of a signal through a  
 inflammation (in-fla-MAY-shun) - a red and painful swelling  
 involuntary (in-VAHL-un-tair-ee) - not voluntary; without  
 motor cortex (MO-ter KOR-tex) - the region of the cerebrum  
     voluntary movement  
 motor neuron (MO-ter NU-rahn) - a type of nervous system  
     spinal cord, that sends impulses causing movement  
 nerve (NERV) - bundle of neuron fibers  
 nervous system (NER-vus sis-tum) - the brain, spinal cord,  
 neurologist (nu-RAHL-uh-jist) - a medical doctor specializing  
     disease and injury in the nervous system  
 neurology (nu-RAHL-uh-gee) - a branch of medical science  
 neuron (NU-rahn) - a cell of the nervous system that conducts  
     another  
 neuroradiologist (nu-ro-ray-dee-AHL-uh-jist) - a medical doctor  
     the body (X rays and others) to identify injury and disease  
 neuroscience (nu-ro-SY-ens) - a branch of science related to  
 neurosurgeon (nu-ro-SUR-jun) - a medical doctor who specializes  
     cord and nerves  
 neurosurgical nurse (nu-ro-SUR-ji-kul NURS) - a nurse who  
     perform surgery on the nervous system with a neurosurgeon  
 paralysis (puh-RAL-uh-sis) - loss of the ability to move  
 paraplegia (pair-uh-PLÉE-juh) - partial or complete inability  
     usually the loss of use of both legs resulting from spinal cord  
 patella (puh-TEL-uh) - kneecap bone

neuron fiber  
g caused by injury or infection  
thought or control  
um responsible for starting and controlling

m cell, originating in the brain or the

and network of neurons in the body  
ng in the diagnosis and treatment of

e which deals with the nervous system  
ects a signal from one part of the body to

doctor who uses pictures of the inside of  
e in the nervous system  
o the study of the nervous system  
cializes in operating on the brain, spinal

o is part of the team of people who  
eon

y to move the lower half of the body;  
ord injury

**patellar tendon** (puh-TEL-er TEN-dun) - a fibrous band  
the large bone of the lower leg (tibia)

**physician** (fih-ZIH-shun) - a medical doctor

**quadriplegia** (kwah-drih-PLÉE-juh) - partial or complete  
usually the loss of use of both arms and both legs result

**reflex** (REE-fleks) - an involuntary motor response to a s  
protection

**rehabilitation** (ree-huh-bil-uh-TA-shun) - the process of r  
restoring the ability to function

**sensory cortex** (SENS-uh-ree KOR-teks) - a portion of the  
information from a particular sense (sight, smell, etc.)

**skeletal** (SKEL-uh-tuhl) - belonging to the framework of f

**skull** (SKUL) - all the bones of the head, including the cra

**spinal cord** (SPY-nuhl kord) - the thin rope of nervous tis

**spine** (SPYN) - a series of connected bones along the back  
(spinal column)

**steroids** (STAIR-oydz) - biological compounds used in the  
including swelling and inflammation

**tendon** (TEN-dun) - a tough band of tissue that connects

**terrain** (tuh-RAIN) - an area of land

**tissue** (TIH-shoo) - many cells of the same kind, joined to

**tracking** (TRAK-ing) - following tracks or a trail, especial

**vegetation** (vej-uh-TAY-shun) - plant life of a particular ar

**voluntary** (VAHL-un-tair-ee) - done on purpose or by cho

**white rhinoceros** (ry-NOS-er-us) - a large, powerful, grass  
gray skin and two horns on its snout

**zoologist** (zo-AHL-uh-jist) - a scientist who studies anima

connecting the kneecap bone (patella) with

paralysis of the body below the neck;

ing from spinal cord injury

ensory stimulus, usually for the purpose of

restoring a person to a condition of health or

the cerebral cortex responsible for processing

bones that supports the body

anium and the facial bones

tissue inside the bones of the spine

x of a skeleton, also known as the backbone

the treatment of many medical conditions,

a muscle to a bone

together to do a specific job

ally in order to find an animal

area

vice

s-eating mammal of Africa, having a thick

ls

• **Grace Boyle** was a teacher in Hempstead, New York for 20 years. She received her Master's in Education Administration from Hofstra University. She developed, coordinated and mentored gifted and talented students in the Hempstead school system. Ms. Boyle has written for several children's book publishers, specializing in activity books that encourage children's curiosity and exploration of the natural world. Her scientific curiosity. Currently, Ms. Boyle is a freelance writer. Her special interests include writing as consultant for her science-based writing.

**T Lewis** was born in Texas but has travelled extensively, living in several countries. Currently, he lives in a small town in the state of Washington with his wife and two children. His artwork has appeared in many formats, he is especially fond of creating children's books. His recent work are *Bedtime Rhymes from Around the World* and *Cinderella: The Story Behind the Fairy Tale*. He has also done a comic strip for Disney Productions and is one of the creators of *Over the Hedge*.

Faculty members in the Division of School-Based Programs at Baylor University have developed and revised instructional materials for the BrainLink® project. Nancy Moreno have been working together at Baylor for several years on projects that involve students from kindergarten through college. All are parents of teenagers. They have created instructional materials for the My Health My World® project that are used by elementary school students.

**Judith Dresden**, originally from New York and New England, has worked in the field of evaluation for public and private schools. Editorial work with a publisher, she has been writing and editing stories and science activities for children. She directs a project that centers around the country. Other projects involve promoting minority health professions.

**Barbara Tharp**, originally from California, once worked for the state of California as an economic analyst for an oil company. More recently, she has been an editor of science subjects, science and math. Currently, in addition to creating educational materials for classroom teachers and their students. She directs elementary school

**Nancy Moreno**, originally from Wisconsin and Michigan, is a biologist. She has spent considerable time studying neotropical plants in Mexico before coming to Baylor. Current interests include involving scientists in pre-college education and science. She directs elementary curriculum development projects and directs the My Health My World® project. Her special interests in ecology and environmental issues.

rs and received her M.S. degree in Elementary  
l and implemented a program for gifted and  
ritten curriculum materials for several textbook  
ritical thinking skills and stories that promote  
n, Dr. Thomas P. Boyle, a Florida radiologist, serves

uch locales as Africa, Switzerland and Alaska.  
wife and young son. While his broad range of  
g illustrations for children. Recent books bearing his  
*the Untold Story*. He has drawn the Mickey Mouse  
*the Hedge*, a comic strip in national syndication.

aylor College of Medicine in Houston, Texas, have  
ject. Judith Dresden, Barbara Tharp and Nancy  
science education projects involving teachers and  
ge or grown children. As a team, they also have  
t, which focuses on environmental health science

ormerly conducted educational research and  
ublishing company also led to her current interest in  
ects the BrainLink project at Baylor and at regional  
ity students' access to careers in science and the

FBI in Washington, D.C., and later was an  
n elementary teacher specializing in her favorite  
ional materials, she also enjoys working with many  
teacher enhancement programs at Baylor.

ologist who specializes in botany. She spent  
pleting her doctoral degree at Rice University.  
a. She oversees the science content of Baylor's  
alth My World project, which builds upon her



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# ACTIVITIES

GUIDE FOR TEACHERS

## Motor Highways

Revised Edition

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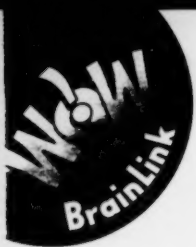
The activities described in this book are intended for school-age children under direct supervision of adults. The authors, Baylor College of Medicine and the publisher cannot be responsible for any accidents or injuries that may result from conduct of the activities, from not specifically following directions, or from ignoring cautions contained in the text.

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### Science and Health for Kids!

These BrainLink Activities are designed to be used with other components of the Motor Highways unit:

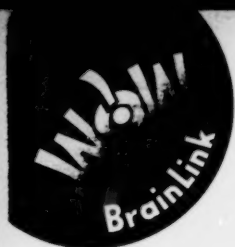
#### BrainLink Adventures

*Trouble at Tsavo: The NeuroExplorers™ in the Tale of the Black Rhinos*

#### BrainLink Explorations

*Motor Highways*





## ACKNOWLEDGMENTS

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**"The brain is the last and grandest biological frontier, the most complex thing we have yet discovered in our universe. It contains hundreds of billions of cells interlinked through trillions of connections. The brain boggles the mind."**

James D. Watson  
from *Discovering the Brain*  
National Academy Press  
1992





## ABOUT BRAINLINK - Science and Health for Kids!

The BrainLink Project's exciting *Activities*, *Explorations* and *Adventures* "link" students, teachers and parents to advanced knowledge of the brain and nervous system and to vital science and health information. Prepared by teams of educators, scientists and health specialists, each BrainLink unit focuses on a different aspect of the brain and the nervous system. The activity-based, discovery-oriented approach of the BrainLink materials is aligned with the *National Science Education Standards* and the *National Health Education Standards*.

The three components of each BrainLink unit help students learn why their brains make them special.

- *BrainLink Adventures* presents the escapades of the NeuroExplorers Club in an illustrated storybook that also teaches science and health concepts.



- *BrainLink Explorations for Children and Adults* is a colorful mini-magazine full of information, activities and fun things to do in class or at home.



- *BrainLink Activities - Guide for Teachers* presents activity-based lessons that entice students to discover concepts in science, mathematics and health through hands-on activities.



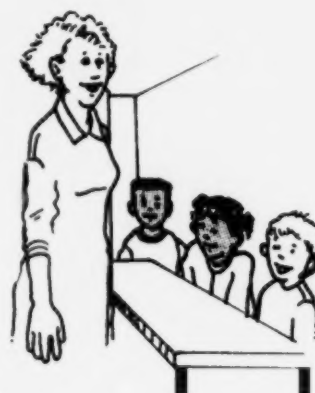
BrainLink materials offer flexibility and versatility and are adaptable to a variety of teaching and learning styles.

## WHERE DO I BEGIN?

The *Adventures*, *Explorations* and *Activities* components of each BrainLink unit are designed to be used together to introduce and reinforce important concepts for students. To begin a BrainLink unit, some teachers prefer to generate students' interest by reading part or all of the *Adventures* story. Others use the cover of the *Explorations* mini-magazine as a way to create student enthusiasm and introduce the unit. Still others begin with the first discovery lesson in the *BrainLink Activities - Guide for Teachers*.

If this is your first BrainLink unit, you may want to use the pacing chart on the following page as a guide to integrating the three components of the unit into your schedule. When teaching BrainLink for 45 to 60 minutes daily, most teachers will complete an entire BrainLink unit with their students in two to three weeks. If you use BrainLink every other day or once per week, one unit will take from three to nine weeks to teach, depending on the amount of time you spend on each session.

The *BrainLink Activities - Guide for Teachers* provides background information for you, the teacher, at the beginning of each activity. In addition, a listing of all materials, estimates of time needed to conduct activities, and links to other components of the unit are given as aids for planning. Questioning strategies, follow-up activities and appropriate treatments for student-generated data also are provided. The final activity in each *BrainLink Activities - Guide for Teachers* is appropriate for assessing student mastery of concepts.



## Using Cooperative Groups in the Classroom

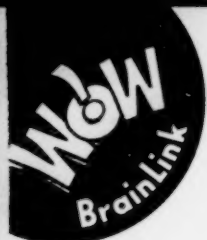
Cooperative learning is a systematic way for students to work together in groups of two to four. It provides an organized setting for group interaction and enables students to share ideas and to learn from one another. Through such interactions, students are more likely to take responsibility for their own learning. The use of cooperative groups provides necessary support for reluctant learners, models community settings where cooperation is necessary, and enables the teacher to conduct hands-on investigations with fewer materials.

Organization is essential for cooperative learning to occur in a hands-on science classroom. There are materials to be managed, processes to be performed, results to be recorded and clean-up procedures to be followed. When students are "doing" science, each student must have a specific role, or chaos may follow.

The Teaming Up model\* provides an efficient system. Four "jobs" are delineated: Principal Investigator, Materials Manager, Reporter and Maintenance Director. Each job entails specific responsibilities. Students wear job badges that describe their duties. Tasks are rotated within each group for different activities, so that each student has an opportunity to experience all roles. Teachers even may want to make class charts to coordinate job assignments within groups.

Once a cooperative model for learning has been established in the classroom, students are able to conduct science activities in an organized and effective manner. All students are aware of their responsibilities and are able to contribute to successful group efforts.

\* Jones, R. M. 1990. Teaming Up! LaPorte, Texas: ITGROUP.



## Motor Highways

### Sample Sequence of Activities, Adventures and Explorations

The components of this BrainLink unit can be used together in many ways. If you have never used these materials before, the following outline might help you to coordinate the activities described in this book with the unit's *Adventure* story (*Trouble at Tsavo*) and *Explorations* mini-magazine (*Motor Highways*).

Similar information also is provided for you in the Links section of each activity in this book.

| Activity                  | Concepts                                                            | Class Periods<br>to Complete<br>Activity | Links to Other Components of Unit                                 |                                                 |
|---------------------------|---------------------------------------------------------------------|------------------------------------------|-------------------------------------------------------------------|-------------------------------------------------|
|                           |                                                                     |                                          | Adventures:<br>Trouble at Tsavo                                   | Explorations:<br>Motor Highways                 |
| 1. Signals and Synapses   | Muscles and the nervous system work together for movement.          | 1                                        | Read: Tennis Anyone?; A Call to Order; A New NeuroExplorer        | Cover page activity                             |
| 2. Make a Neuron          | The brain is shielded by the skull, which also needs protection.    | 1                                        | Read: Poachers at Tsavo; Trek to Moldavi Pass; Spinal Cord Puzzle | Cover page activity; Gray Matters (pp 2-3)      |
| 3. Eye Openers            | Involuntary movements such as reflexes happen without thinking.     | 1                                        | Read: A Good Question; The Black Rhinoceros                       | The Neuro Side (p 7); Betcha Can't (p 8)        |
| 4. Real Knee Jerkers      | The knee jerk reflex is processed through the spinal cord.          | 1                                        | Read: Caught by Surprise                                          | Gray Matters (pp 2-3); Betcha Can't (p 8)       |
| 5. Practice Makes Perfect | Voluntary movements are directed by the motor cortex.               | 1                                        | Read: On Top of the Brain                                         | Can You Teach An Old Hand New Tricks? (6)       |
| 6. Take a Walk            | Programs for well-learned movements are stored in the cerebellum.   | 1                                        | Read: Rumbling Thunder                                            | Gray Matters (pp 2-3); The Neuro Side (p 7)     |
| 7. My Motor Strip         | Different areas of the motor cortex direct different muscle groups. | 1                                        | Read: Knee Jerk Reaction                                          | Motor System drawing shown on page 3            |
| 8. Motor Model            | The spine protects the spinal cord. Spinal damage affects movement. | 1                                        | Read: An Unexpected Flight                                        | Spinal Cord Critter (p 5); Use Your Brain (p 4) |
| 9. Moving Biographies     | Neuron pathways for movement are disrupted in some diseases.        | 1 or more                                | Read: New Beginnings (concludes story)                            | Decade of the Brain (p 4); Careers (p 7)        |
| 10. NeuroKids             | Summary and assessment activity                                     | 1 or 2                                   | Review science boxes throughout                                   | Cover activity; Gray Matters (pp 2-3)           |



## Materials

You will need the following materials to teach this unit.

- notecards (one per student for Activity 1 and one per group of students for Activity 3)
- ball of string (or safety pins) (Activity 1)
- pipe cleaners (several per student) (Activities 2 and 7)
- styrofoam spheres or a ball of clay or play dough for each student (Activity 2)
- masking tape (Activity 2)
- penlights or small flashlights (one per group of students) (Activity 3)
- rubber percussion hammers (one per group of students) (optional for Activity 4)
- wall clock or individual watches with second hands (Activity 5)
- chopsticks (one pair for every two students) (Activity 5)
- small objects, such as uncooked pasta, jacks, hardware, etc. for students to pick up using chopsticks (Activity 5)
- rulers (one per student or group) (Activities 7 and 8)
- scissors (one per student or group) (Activities 7 and 8)
- play dough or clay in three colors: yellow, red and blue (Activity 8) (see recipe at right to make "brain dough")
- sheets of card stock (one per student) (Activity 8)
- clear tape (Activity 8)
- white glue (Activity 8)
- colored markers or crayons (Activities 8 and 10)
- small box of paper clips (Activity 8)
- plastic drinking straws (one per student) (Activity 8)
- two different colors of thin yarn or embroidery thread (12 inches of each color per student) (Activity 8)
- wide paper (2 meters in length for each group) (Activity 10)

**Call 1-800-969-4996  
for information about  
BrainLink printed  
materials and supplies.**

### Brain Dough

#### Ingredients

2 cups flour  
2 cups water  
4 teaspoons cream of tartar  
 $\frac{1}{4}$  cup vegetable oil  
1 cup salt  
food coloring (optional)

1. Combine flour, water and cream of tartar in a large bowl or blender. Mix until lumps disappear.
2. Add oil and food coloring, if desired.
3. Put mixture in a saucepan and add salt. Stir and cook over low heat until mixture becomes lumpy.
4. Empty mixture from saucepan and let it cool. Knead to smooth out lumps.

# Signals and Synapses

## BRAINLINK BACKGROUND (for the teacher)

The basic building block of the nervous system is the nerve cell, or neuron. Within the body, neurons form vast communications networks in which they are linked with one another, as well as with muscles, sensing organs and other structures.

Billions of neurons form the command center of the body, the brain. The brain connects at the base of the brainstem to the spinal cord—a thick bundle of nerve fibers that runs inside the spine. Together, the brain and spinal cord make up the central nervous system. The remaining network of nerves throughout the body and head constitutes the peripheral nervous system. The complete nervous system is made up of the brain, the spinal cord, and all of the nerves and associated cells.

Only certain portions of the nervous system are involved in producing movement of the body or parts of the body. In this guide, we refer to the parts of the nervous system that are involved in movement as “motor highways” or “pathways.” All of the motor pathways, from the simplest to the most complex, involve transporting messages along components of the nervous system. Some messages travel from the brain and spinal cord to the muscles. Other messages are transported from sensing organs like ears and skin, as well as from muscles, to the central nervous system.

Two types of neurons carry information necessary for motor function.

- *Motor neurons* conduct signals from the brain or spinal cord to muscles that stimulate them to shorten (contract) or lengthen (relax).
- *Sensory neurons* carry information from sensing organs such as eyes, ears, nose, tongue and skin, as well as information about what the muscles are doing, to the spinal cord and brain.

The nervous system and muscles act together to achieve movement of or within the body. Signals that trigger movement are generated in the brain or spinal cord and then travel along motor neurons to the muscles. The signals travel very rapidly along the nerve cells and are transmitted chemically or electrically from one neuron to another across tiny gaps called synapses. Signals also are sent from muscles and sensing organs along sensory neurons to the spinal cord or brain as part of a complex system of interactions.

## ACTIVITY 1

### CONCEPTS

- The basic building block of the nervous system is the neuron.
- Neurons transport messages within the body.
- The muscles and the nervous system work together to achieve movement.

### OVERVIEW

Using a simple game, students model how signals are sent along nerve cells within the body to achieve movement.

### SCIENCE & MATH SKILLS

Problem solving, modeling and inferring

### TIME

Preparation: 10 minutes

Class: 30-45 minutes

### MATERIALS

- notecards or other paper to make badges (one per student)
- string or safety pins to attach badges

The human nervous system contains around  $10^{20}$  neurons!





In this activity, students will model the simplest kind of interaction among the brain, motor and sensory neurons, and the muscles. Working in teams, students will devise a message-sending system that will allow the "brain" to send a message along "motor neurons" to a "muscle." "Sensory neurons" will respond by sending a message back to the "brain" about whether the "muscle" carried out the instructions.

## LINKS

This activity may be taught along with the following components of the Motor Highways unit.

### ***Trouble at Tsavo chapters:***

Tennis Anyone?

A Call to Order

A New NeuroExplorer (see science box on page 5)

NOTE: If this is your students' first BrainLink Adventure story, have them read the introductory sections, The Beginning and The Club Members, before continuing with the rest of the book.

### ***Explorations:***

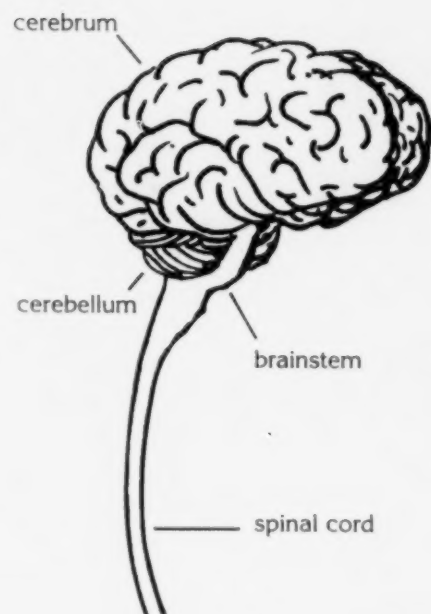
Cover page activity

## SET-UP

Conduct the initial portion of this activity with the entire class. Then divide the class into groups of four students.

## PROCEDURE

1. Before beginning any discussion, have the students sit very quietly in their seats. Ask, *Is anyone moving?* After students have had a chance to reply, ask, *Is any part of your body moving?* Give students time to think about their answers—they might mention that their ribcages are moving as they breathe or that someone's eyelid moved as he or she blinked, etc.
2. Now, ask everyone to stand and jump or turn around. Ask, *What is moving now?* List the different parts of the body mentioned by students on the board. Explain that all of the movements that they have mentioned, including the automatic ones that they noticed while they were sitting quietly, are directed and controlled by the nervous system. They will now begin to explore how the brain and rest of the nervous system direct movement by sending signals to the muscles of the body.
3. Ask the students if they have ever played a game in which they pass a message around a circle. Let them discuss the different ways in which they have played games of this type.



The brain and spinal cord make up the central nervous system.

4. Explain that the body also has ways to send messages from one part to another. The message carriers are cells called "neurons." Mention that the brain is made up of billions of interlinked neurons and that neurons communicate with one another, with muscles, with sensing organs like eyes and ears, and with other organs in the body. Point out that neurons manage to pass signals from one to another without actually touching.
5. Divide the class into groups of 4 students. Each group will have one student as the "brain," one student as a "motor neuron," one student as a "muscle," and one student as a "sensory neuron." Each student should create a badge identifying his or her role, using a notecard, paper plate or piece of construction paper.
6. Let the members of each group wear their respective badges as they brainstorm ways in which a message could be sent from brain to muscle and back without physical contact between students. Talk about the basic sequence of events that occurs when a movement is initiated. *The brain sends a signal along one or more motor neurons to a muscle. The muscle reacts as instructed, and sensors within the muscle send a new signal back to the brain along sensory neurons. The return signal lets the brain know that the action has taken place.*
7. Each group should devise its own message-sending system between the muscle and the brain (speaking not allowed!). An example would be for students to pass a written note from "brain" to "motor neuron" to "muscle" requiring the muscle to perform a particular action (stand up, raise hand, etc.). After reacting, the muscle would send its own message back to the brain through the sensory neuron.
8. Allow time for each group to present its message-sending system to the rest of the class.



Have students brainstorm a way to send messages between "brain" and "muscle."

## BRAIN JOGGING

*Here are more ideas for you and your students to explore.*

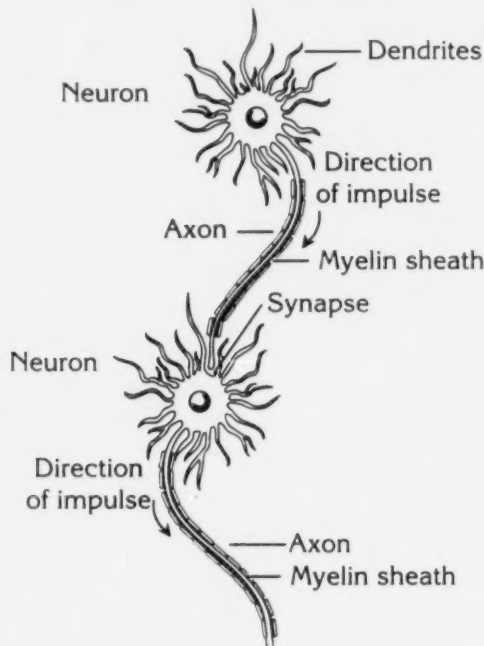
- Why is it important for one part of the body to communicate with another? What would happen if your stomach could not tell your brain that it was full, or your hand could not signal that it was touching something hot?
- The word "neuron" comes from the Greek language. After reading the introduction to *Trouble at Tsavo*, how many words could you find that are made from the same root as neuron. Try creating your own "neuro-" words!

## Make a Neuron

### BRAINLINK BACKGROUND (for the teacher)

Within the nervous system, each neuron transmits messages along tail-like branches known as *axons*. Messages are received on the cell body and on tree-like branches known as *dendrites*.

Although neurons are microscopic, the dendrites and axons (also known as nerve fibers) can be very long. Some axons exceed one meter in length and extend from the brain into the lower part of the spinal cord or from the spinal cord into the arms or legs. The word *nerve* is used in a general sense to describe a bundle of nerve fibers and associated cells.



### Message Carriers of the Nervous System

Other types of cells in the nervous system include specialized receptors (like those in the eye or ear), cells that supply nutrients to neurons, and cells that insulate nerve fibers. The insulating cells form a segmented fatty shield, called a *myelin sheath*, that allows nervous signals to travel faster.

*Gray matter* refers to nervous system tissue that is composed primarily of cell bodies and nerve fibers without a myelin sheath. Gray matter makes up much of the brain and the central core of the spinal cord. Nerve fibers covered with a myelin sheath are described as *white matter* and are present in the brain, spinal cord and nerves.

## ACTIVITY 2

### CONCEPTS

- Neurons have special parts that are important for sending and receiving messages or signals.
- There are many different kinds of neurons.

### OVERVIEW

Students are introduced to the neuron by creating a three-dimensional model of one neuron (or nerve cell).

### SCIENCE & MATH SKILLS

Modeling and inferring

### TIME

Preparation: 10 minutes

Class: 30-45 minutes

### MATERIALS

- pipe cleaners (several per student)
- styrofoam spheres (1-2 inches in diameter), clay or play dough (enough for each student to have one sphere or ball of clay or play dough; if you prefer to make your own "Brain Dough," see recipe on page vi)
- 1 roll of masking tape
- overhead transparency or copies of "Know Your Neurons" and "Neurons and More Neurons" (pages 7-8)

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## LINKS

This activity may be taught along with the following components of the Motor Highways unit.

*Trouble at Tsavo* chapters:

Poachers at Tsavo

Trek to Moldavvi Pass

A Spinal Cord Puzzle (see science box on page 12)

*Explorations:*

Cover page activity

Gray Matters (pages 2 and 3)

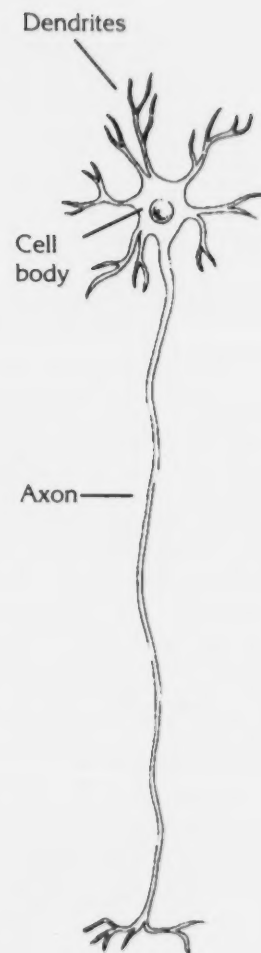
## SET-UP

Conduct this activity with the entire class. Students should work in teams or small groups to share resources as they build their individual neuron models.

If students are using Styrofoam spheres for their models, make several holes in each sphere for them before beginning the activity. Push a knitting needle or skewer through each sphere in several places. See the Brain Dough page for a recipe for making your own modeling dough, if you prefer to use it instead of the spheres or a purchased modeling clay.

## PROCEDURE

1. Project an overhead transparency or distribute copies of the Know Your Neurons page. Mention that neurons send messages along long branches called axons. Help students find the longest branches on the neurons shown in the drawing. *These are the axons.* Next, have them find the shorter branches. *These are called dendrites.* Messages from other neurons are received on the dendrites and sometimes on the cell body. Point out the myelin sheath surrounding the axon (looks like a string of beads). Have students label the parts.
2. Tell students that they will create their own neuron models. Show the Neurons and More Neurons page at this point to give them some ideas about the variety of neurons that exist in the body. Point out the axons and dendrites on the different types of neurons.
3. Place pipe cleaners, styrofoam balls or play dough or clay and masking tape in a central location. Have the materials managers pick up enough materials for each member of the group.



Typical motor neuron

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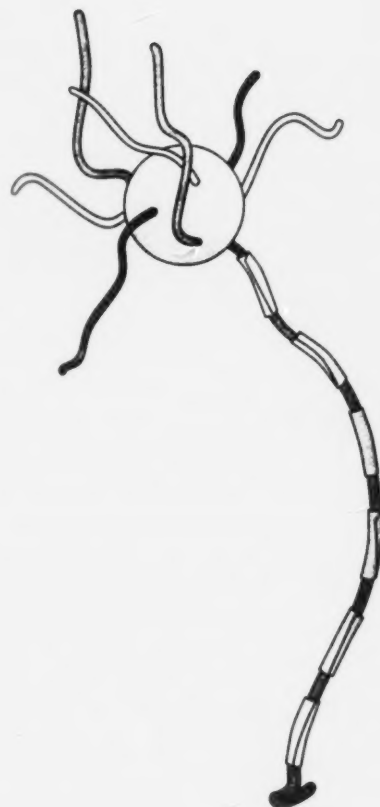
4. If using modeling clay, have students roll their material into a ball to create the bodies of the nerve cells. Direct them to insert pipe cleaners through the cell bodies of their models (foam spheres or balls of clay or dough) to create branches (dendrites).
5. Tell the students to create an axon on each of their models by attaching an extra pipe cleaner to one of the pipe cleaner branches.
6. Have them wrap one inch sections of masking tape at 1/8 to 1/4 inch intervals along the "axon" to represent the myelin sheath.
7. Let students share their neuron models with the rest of the class or display them in the classroom or on a bulletin board.

### BRAIN JOGGING

*Here is another idea for you and your students to explore.*

Someone might say, "Her synapses are really firing today." What might such a statement mean? What would happen if synapses were not firing?

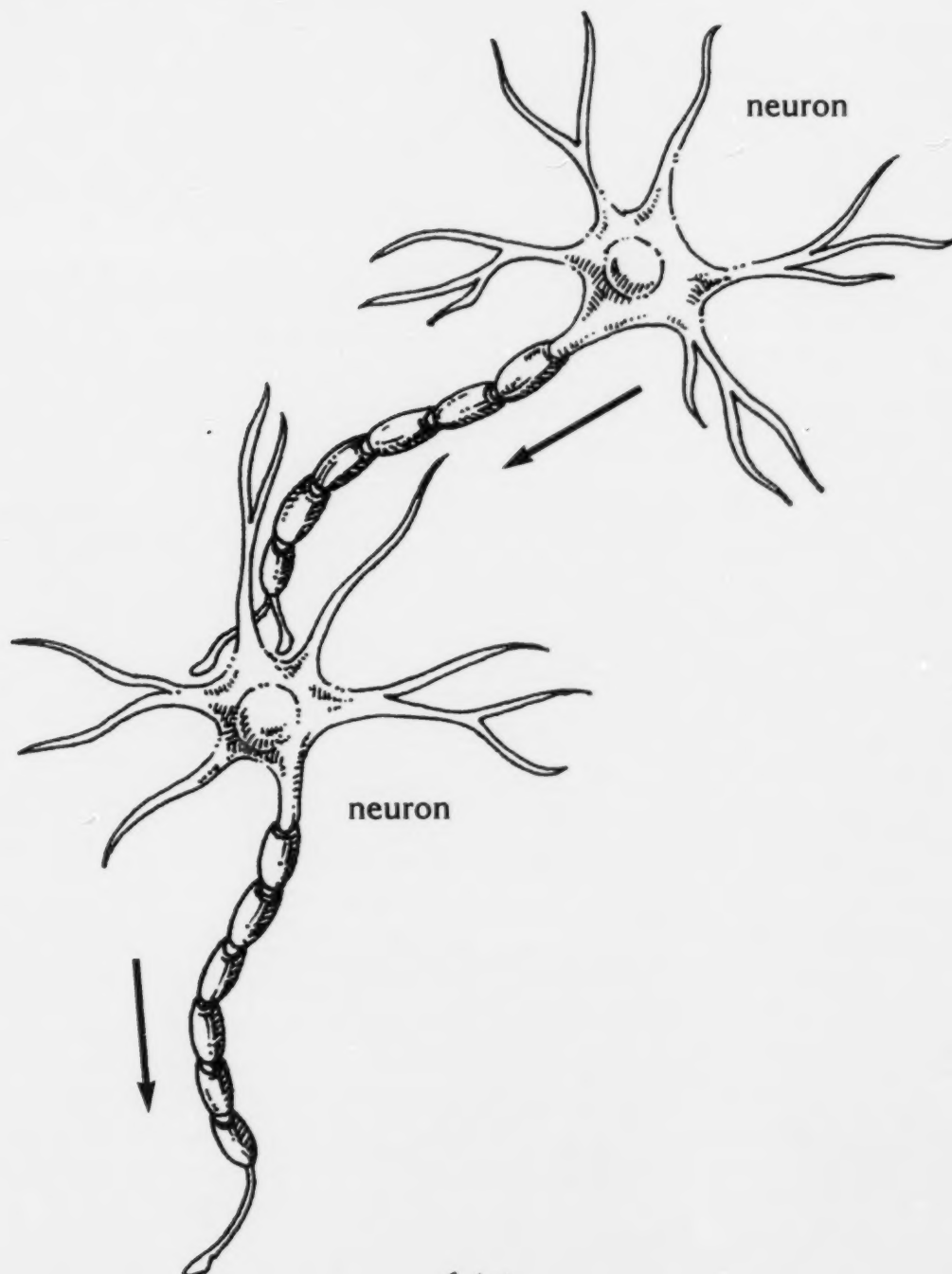
NOTE: Synapse firing refers to the chemical or electrical transmission of signals from one neuron to another across the synapses—tiny gaps between cells.



Students will create their own neuron models.

## Know Your Neurons

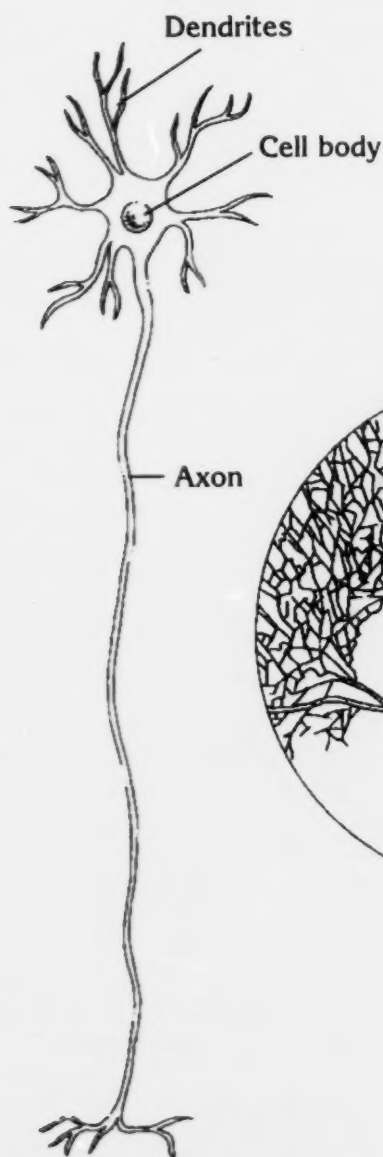
Find the long branches (axons) leading from one neuron to the next. Find the short branches (dendrites). Can you see the tiny space between the neurons (synapse)? Did you find the myelin sheath covering the axon? Label the parts of the neurons.



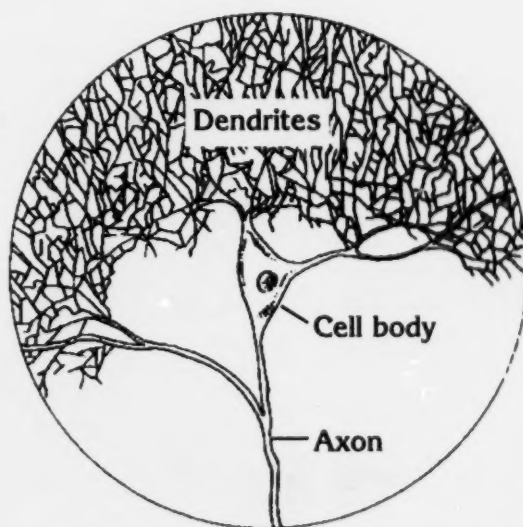
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## Neurons and More Neurons

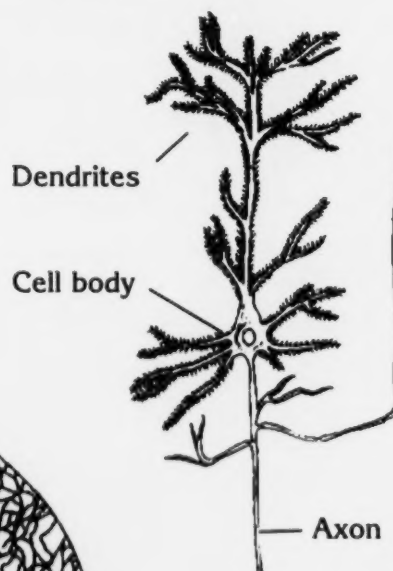
There are over 10,000 kinds of neurons in the human body! Pictured below are examples of four different neurons. Some neurons are simple structures in which the axon and dendrites are easily identified. Others are very complicated, with hundreds of tiny branches.



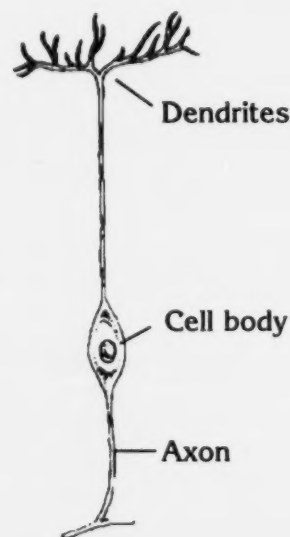
Motor neuron from the spinal cord



Neuron from the cerebellum



Neuron from the hippocampus  
(important for memory and learning)



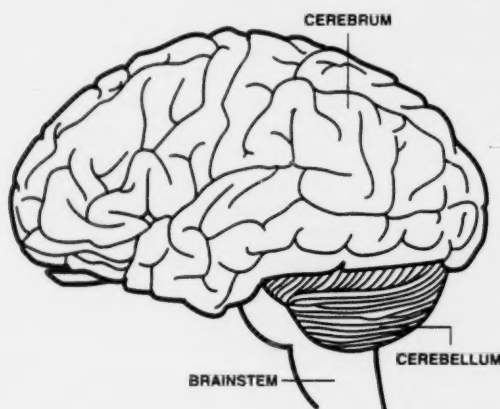
Sensory neuron from the eye

# Eye Openers

## BRAINLINK BACKGROUND (for the teacher)

### No Thinking Required!

Many movements of our bodies happen automatically. Some of them, such as breathing, movement of food through the digestive system and beating of the heart, help keep all parts of the body working properly. Automatic functions like these are regulated primarily by the brainstem.



Other automatic movements occur as a response to a stimulus or a sudden change in conditions (such as exposure to a bright light or coming in contact with something very hot or very cold). These movements, which include pulling away quickly from something hot or sharp, or the adjustment of the pupil of the eye in response to sudden bright light, are called *reflexes*. Reflexes that involve muscles of the face or head are directed through pathways in the brainstem. Other reflexes follow pathways in the spinal cord, as will be examined in Activity 4: Real Knee Jerkers. Many reflexes help protect the body from harm, such as startle reflex or blinking. Others play a role in the coordination of complex movements involving many muscles, such as the *patellar* or *knee jerk reflex*.

Reflex responses are rapid because they follow simple pathways that do not include the cerebrum or the cerebellum. In a typical reflex, sensory neurons communicate directly with motor neurons at a central point in the spinal cord or in the brainstem. The motor neurons receive the signals and immediately stimulate the appropriate muscles to respond. The thinking part of the brain does not enter into the signal-response loop, which sometimes is referred to as a *reflex arc*.

## ACTIVITY 3

### CONCEPTS

- Involuntary movements happen without thinking about them.
- Reflexes are a kind of involuntary movement.
- Some reflexes are processed through the brainstem.

### OVERVIEW

Students learn about reflexes as they investigate the effect of bright light on pupil size.

### SCIENCE & MATH SKILLS

Predicting, observing and drawing conclusions

### TIME

Preparation: 10 minutes

Class: 30 minutes

### MATERIALS

Each group of students will need:

- penlight or small flashlight
- index card

Reflexes and automatic body functions are considered *involuntary movements*. These types of movements, which are essential for survival, are governed by the most primitive parts of the nervous system—the brainstem and the spinal cord. No thinking is required! Even very primitive animals show simple reflex responses and have a central nervous system that governs basic body functions.

### **Pupil Reflex**

When you look at a bright light, the pupils in your eyes automatically become smaller. This is a reflex response triggered by too much light. The light is detected by sensory neurons at the back of the eye that transmit messages to the brainstem region of the brain. There, the message is received by neurons that signal muscles of the iris to reduce the size of the pupil. The thinking part of the brain also receives a message about the presence of potentially harmful bright light. However, by the time you think to shield your eyes, your pupils already have reacted.

Surprisingly, both pupils always will contract together, even if only one eye is exposed to bright light. This happens because the sensory neurons that detect light in each eye form synapses in the brainstem with motor neurons for both pupils. In other words, they are “wired” together!

### **LINKS**

This activity can be taught along with the following components of the Motor Highways unit.

#### ***Trouble at Tsavo* chapters:**

A Good Question (see science box on page 15)

The Black Rhinoceros

#### ***Explorations:***

The Neuro Side (page 7)

Betcha Can't (page 8)

### **SET-UP**

After a class discussion, have students work in groups of 2-4. Place penlights and notecards in a central location for the materials managers to collect.

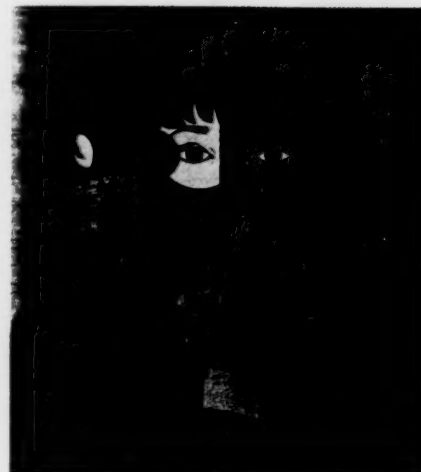
### **PROCEDURE**

1. Ask students a few questions to introduce the concepts of involuntary movements and reflexes. *What movements of your body happen even when you are sitting quietly or sleeping? Do you have to think about these movements in order for them to happen? What might happen if you did have to remember to breathe or have your heart beat? How*



*about when you touch something hot? What would happen if you had to think about pulling your hand away?*

2. Mention that many involuntary movements are controlled by the brainstem. Remind students of the brainstem's location at the back of the head above the spinal cord. Mention that they will be exploring one automatic response governed through the brainstem—the pupil reflex.
3. With the students in pairs or small groups, have them observe the pupil reflex. The materials manager of each group should be the “subject” and hold an index card between his or her eyes. Have each principal investigator shine the penlight toward (not directly into!) only one of the subject's eyes. The other members of the group should observe the reactions of both of the subject's eyes. Surprisingly, both pupils will contract, even though only one has been exposed to bright light! If time permits, let students take turns.
4. Discuss the mechanism behind the pupil reflex. *When you go into bright sunlight from a dark room, what happens to your pupils?* (They become smaller.) *How about when you enter a dark room?* (They relax and become larger.) *Why do you think both pupils reacted to the bright light?* Help students understand that the sensory neurons from one eye formed connections or synapses with motor neurons for both eyes. Mention that the pupil reflex travels through pathways from the eye to the brainstem and back to the eye, without involving the cerebrum—the thinking part of the brain.



Shine a light toward one of the subject's eyes, while observing the size of both pupils.

## BRAIN JOGGING

*Here are more ideas for you and your students to explore.*

- Why do you think it might be useful for both eyes to respond to bright light, when only one is exposed to it? Can you think of any other times when different parts of the body might react together?
- Is it possible to control the size of the pupils of your eyes by thinking about it? Can you modify any other reflex responses? For example, can you keep yourself from coughing or blinking?

# Real Knee Jerkers

## BRAINLINK BACKGROUND (for the teacher)

### Spinal Reflexes

Below the head, reflex reactions follow pathways through the spinal cord. For example, when you step on a sharp piece of glass, a reflex response is triggered in your leg. Sensory neurons detect a change on the surface of the skin and transmit signals, via synapses, to motor and other neurons in the spinal cord. The motor neurons immediately react to the signals and instruct the necessary groups of muscles in the leg to contract. You don't lose balance, because muscles in the other leg are signaled to compensate for the change in position. A message also is relayed through the spinal cord to the brain, so that the need for further action can be evaluated. The thinking process, however, is much slower than the reflex response. Thus, only after your foot has been removed from the source of pain does the thinking part of the brain react.

Many reflexes help protect the body from harm. When you pull your hand away from something hot, the speed of the reflex response can save you from being burned. Other reflexes play a role in the coordination of complex movements involving many muscles. For example, feedback loops of reflexes through the spinal cord help maintain balance and posture. Reflex responses are similar in all higher animals, including humans, because they are so important for survival.

### Reflex Testing

By observing some of our reflex responses, doctors can evaluate the general status of our nervous systems. One commonly used test involves the knee jerk reflex. In this test, the doctor taps the large tendon just below the kneecap and observes the movement of the lower leg. Usually, the lower leg immediately straightens upward, because a reflex arc that normally helps coordinate muscles of the lower leg is activated. This type of reflex helps muscle groups work together smoothly.

A few reflexes are present only in infants and disappear with age. Doctors look for some of these in the routine examinations of newborn and very young babies. For example, the suckling reflex is triggered in healthy babies when the corner or midpoint of the lip is stroked very gently. This reflex disappears around the age of three or four months. Most babies will close their hands automatically when an object is pressed gently across the palm. This response also disappears after three or four months of age.

## ACTIVITY 4

### CONCEPTS

- Some reflexes are processed through the spinal cord.
- The "knee jerk" or patellar reflex is an example of a spinal reflex.

### OVERVIEW

Students explore the patellar reflex as they learn about motor responses controlled in the spinal cord.

### SCIENCE & MATH SKILLS

Predicting, observing and drawing conclusions

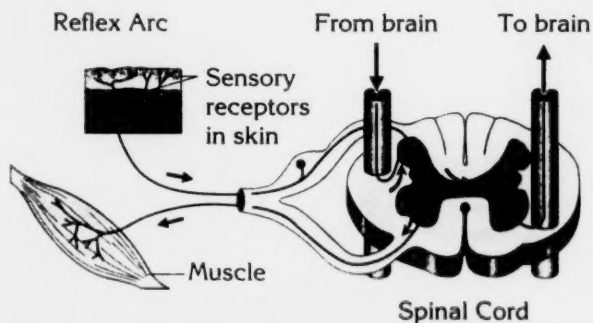
### TIME

Preparation: 10 minutes

Class: 30-45 minutes

### MATERIALS

- rubber percussion hammers (optional)
- overhead transparency or copies of "NeuroKid: Reflex Reactions" on page 14



Pathways of nervous system signals in a typical reflex through the spinal cord. (A pathway from the brain to the spinal cord and muscle also is indicated.)



## LINKS

This activity can be taught along with the following sections of other components of the Motor Highways unit.

Trouble at Tsavo chapter:

Caught By Surprise

Explorations:

Gray Matters (pages 2 and 3)

Betcha Can't (page 8)

## SET-UP

Have students conduct this exploration in groups of 2-4.

## PROCEDURE

1. Demonstrate how to elicit the knee jerk response before allowing students to begin the activity. Sit or have a student volunteer sit on a stool or table edge with legs dangling or with one leg crossed over the other at the knee. Gently tap the crossed knee (or either knee if not crossed) just below the knee cap. A rubber percussion hammer or the side of the hand may be used. When applied correctly, the tap will cause an abrupt forward movement of the lower leg.
2. Divide the students into pairs or small groups. Let them test each other's patellar reflex by tapping a knee, as was demonstrated. Ask the students to describe what happened.
3. Next, ask the students to repeat the reflex response procedure while thinking about not letting their legs move. After they have had some time to explore, ask, *Were you able to stop your leg from jerking by thinking about not letting it move? Why do you think this might be so? Is your brain involved in this kind of reflex?*
4. Discuss the students' observations. Then use an overhead transparency or copies of NeuroKid: Reflex Reactions and help students find the pathways followed by signals in a simple reflex that passes through the spinal cord.

### Note on the Patellar Reflex

It may take several tries for students to locate the correct spot. Some students may need to close their eyes, relax, or concentrate on something else in order to exhibit the reflex. Expect a range in the magnitude of responses and point out that students should not worry if they are unable to produce a knee jerk response in class. Do not use another type of hammer for this activity.

## BRAIN JOGGING

*Here is another idea for you and your students to explore.*

Can you imagine a reflex you wish you had that, as far as you know, you do not have? What stimulus triggers your reflex? What is the purpose or protective function of your reflex? Write a paragraph describing your reflex.

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## NeuroKid: Reflex Reactions



Help! NeuroKid has just touched something hot. What is happening inside? How will NeuroKid's reflexes protect him from being burned?

1. Find NeuroKid's hand. Draw a circle around it. Sensory neurons in his hand will detect something hot.
2. Draw a red line from NeuroKid's hand to his spinal cord. A message from the sensory neurons in his hand will follow this path, saying "Do something, this is HOT!"
3. Draw a blue line from NeuroKid's spinal cord back out to the muscles in his hand and arm. Messages to the muscles will follow this path, saying "Move, NOW!"
4. Finally, NeuroKid's brain also will learn what has happened. Draw a green line from the same place in the spinal cord up to NeuroKid's cerebrum.

Why does NeuroKid say, "Ouch!" after he has already pulled his hand away? Has this ever happened to you?

# Practice Makes Perfect

## BRAINLINK BACKGROUND (for the teacher)

As has been seen in the previous two activities, *involuntary movements* (automatic functions of the body and reflex responses) happen without first involving the thinking part of the brain. Such movements are essential for basic survival and are governed through the brainstem and/or spinal cord. These, of course, are not all of the movements that we carry out in a typical day. Our other movements, such as reaching to pick up a pencil, walking across a room or raising a glass for a sip of water, require a conscious decision. Movements like these are called *voluntary*, because we choose to carry them out. Voluntary movements always are initiated in the cerebrum—the thinking part of the brain.

Voluntary movements range from activities you have never done before to movements you perform every day without thinking very much about them. Included are such diverse actions as raising a hand in class, bouncing a basketball and dancing. Even actions that eventually become routine, such as walking, are considered voluntary, because they require conscious decisions to start and stop.

Whenever you begin to learn a new movement or sequence of movements, like roller skating or playing a new song on the piano, you must concentrate very hard on what you are doing. As you become skilled at the movements, you no longer need to concentrate as intently. Eventually, the movements become almost automatic, but you still control them by thinking about them. Improving with practice is an important characteristic of voluntary movements.

Many neuroscientists believe that voluntary movements are started in scattered regions of the cerebrum. Neurons from these diverse "thinking areas" communicate with a special area of the cerebrum, known as the *motor cortex*. This strip of cerebrum, located across the top of the head (about where you might wear headphones), formulates a plan of action and sends it to the muscles. Messages travel from the motor cortex to muscles in the head (for talking, for example) along neurons in the brainstem. For muscles in the rest of the body, messages travel from the motor cortex along neurons in the brainstem and spinal cord. At appropriate places in the brainstem or spinal cord, the signals connect with motor neurons and trigger contraction (or relaxation) of the needed groups of muscles.

## ACTIVITY 5

### CONCEPTS

- Voluntary movements require conscious thought or planning.
- Voluntary movements improve with practice.
- A special part of the cerebral cortex initiates voluntary movement.
- Programs for movements that are learned and practiced are transferred to the cerebellum.

### OVERVIEW

Students learn about voluntary movements and experience the effect of practice on new motor skills.

### SCIENCE & MATH SKILLS

Predicting, making quantitative observations, graphing and drawing conclusions

### TIME

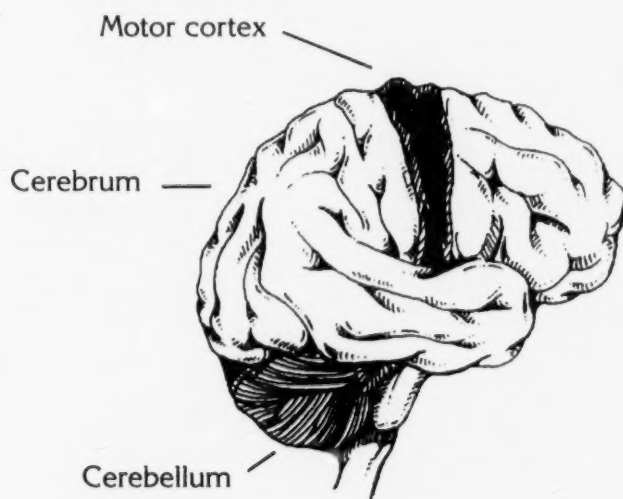
Preparation: 10 minutes

Class: 45 minutes

### MATERIALS

- chopsticks (one pair for every two students)
- small objects to pick up with chopsticks (large pieces of uncooked pasta, jacks, small erasers, etc.)
- individual watches or large clock with a second hand
- overhead transparency or copies of "NeuroKid: Voluntary Movement" on page 18

The motor highways traveled by neuron signals change as you become proficient at a motor task. If you are performing an action that is new to you (for example, when you first learn to ride a skateboard, to type on a keyboard, or perform the exercises in this activity), all of the movements will be controlled by the cerebrum. At first, you might be slow and awkward. However, as you become skilled at the movements, the instructions to the motor cortex will come from the cerebellum instead of from the cerebrum. Your cerebellum "learns" new tasks as you repeat them over and over. Practice does make perfect!



In the following activity, students will be asked to perform a movement that they probably never have done before. They will find that, as they practice, they will be able to perform the movement more rapidly and with greater ease.

### LINKS

This activity may be taught along with the following components of the Motor Highways unit:

#### ***Trouble at Tsavo chapter:***

On Top of the Brain (see science box on page 22)

#### ***Explorations:***

Gray Matters (pages 2 and 3)

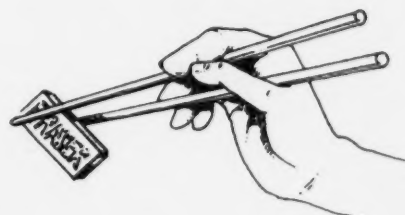
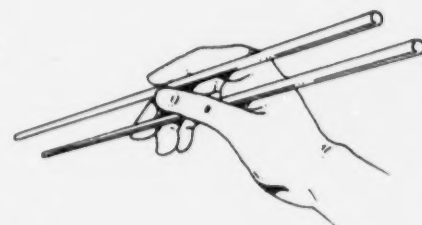
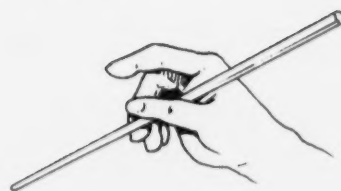
Can You Teach A New Hand Old Tricks? (page 6)

### SET-UP

If possible, have students work in teams to conduct this activity. Otherwise, conduct the activity with 3 or 4 students in each group.

## PROCEDURE

1. Have the materials manager of each team collect a set of chopsticks and 10 small objects from a central area in the classroom.
2. The other member of the team should place the chopsticks in the hand he or she uses for writing, as shown in the illustration on this page. If necessary, demonstrate how to hold chopsticks for the class. If a student already is proficient in the use of chopsticks, he or she should carry out this activity with the other (non-dominant) hand.
3. Without allowing any time for practice, have one student in each team measure the amount of time it takes for the other student to move 10 objects into a pile using the chopsticks. The timekeeper should record the amount of time.
4. Let the students with chopsticks practice using them for approximately five minutes.
5. Now, have the timekeepers measure how much time it takes for the students with chopsticks to move 10 objects again—after having practiced. They should record this value.
6. Have the students switch roles and perform the tests again.
7. Create a graph of the class's results, using one color of paper or "sticky" notes for the times without practice and a second color for the times after practice.
8. Ask, *What happened after you practiced using the chopsticks? How much more practice might you need to be able to eat efficiently using chopsticks?* Mention that different parts of the brain have been involved in the learning process students have just experienced. Project or distribute the NeuroKid: Voluntary Movement page. Help students find the motor cortex and the cerebellum. Then, ask them to find the pathways that messages followed in the nervous system as they learned how to use the chopsticks, as is depicted on the NeuroKid page.



How to hold and use chopsticks

## BRAIN JOGGING

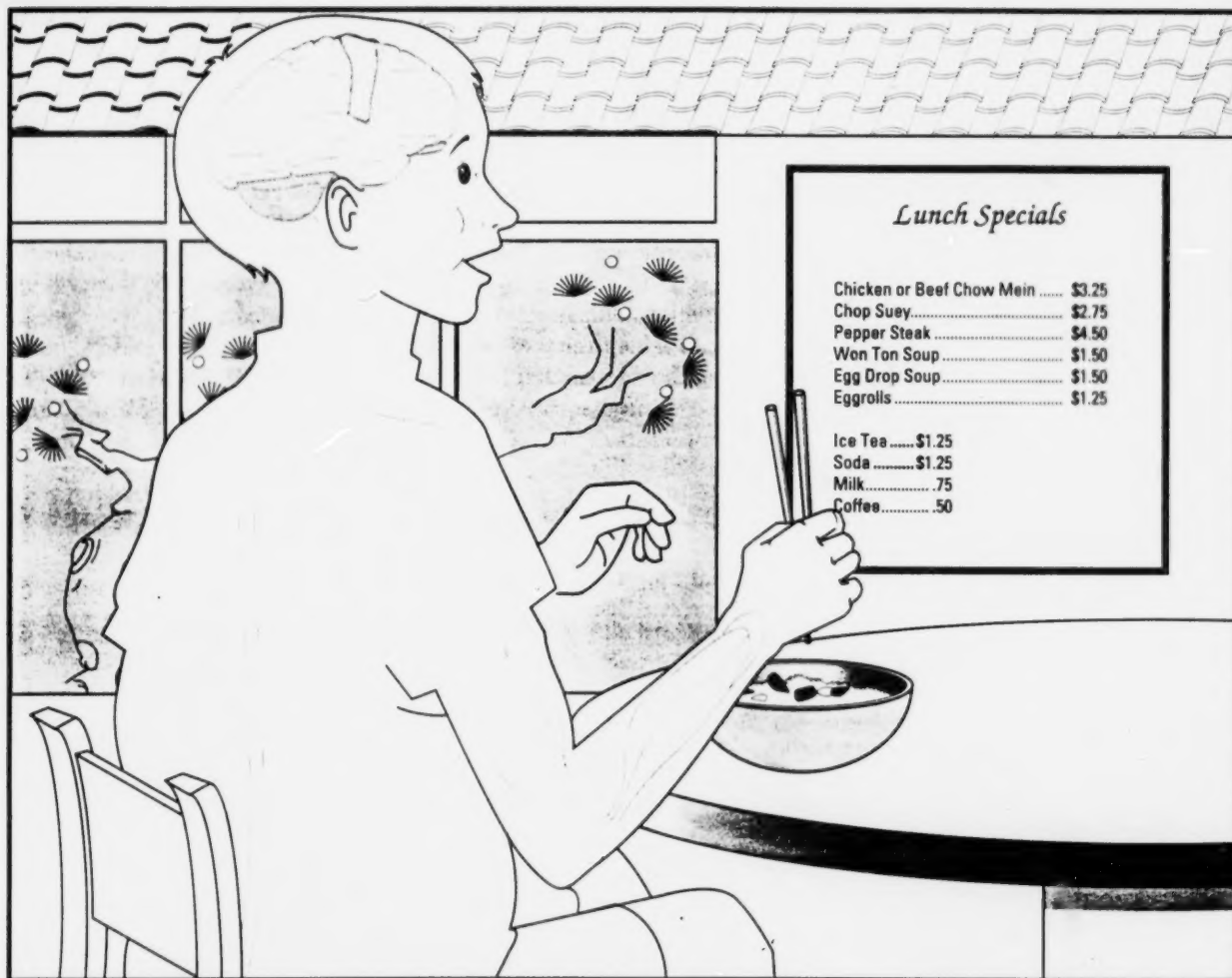
*Here are more ideas for you and your students to explore.*

- Can you move your ear without touching it? Would you consider this voluntary or involuntary?
- Why do you think you can run faster and more smoothly than a two year old? Do you think practice is the most important way to become a good runner?

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# NeuroKid: Voluntary Movement



NeuroKid wants to use chopsticks. Can you help him? Trace the paths messages must follow in his nervous system.

1. Find NeuroKid's cerebrum. Color it yellow. The thought to begin starts here.
2. Find NeuroKid's motor cortex. Color it black. The message to the muscles starts here.
3. Draw a red line from the motor cortex into NeuroKid's spinal cord. Messages will follow this path.
4. Draw a blue line from the spinal cord out to the muscles in NeuroKid's arm and hand. This message tells the muscles to move.

Do you think NeuroKid finally was able to use the chopsticks?

# Take a Walk

## BRAINLINK BACKGROUND (for the teacher)

As was shown in the preceding activity, voluntary movements that you need to think about occur much more slowly than other movements, like reflexes. The thinking part of the brain (cerebral cortex) must make a decision to begin. It also must choose how to proceed. These decisions take time. As you become skilled at a motor activity, you gradually perform the movements more rapidly than when you first attempted them. The cerebellum "learns" and "stores" motor programs for such movements.

Once initiated, certain well-learned voluntary movements that are repetitive and rhythmic can be carried out without thinking about them at all. Examples include walking, running, chewing, bicycling, jogging and skating. Aside from the voluntary aspect of deciding to start and stop these actions, the pattern of movement takes place repetitively, in a reflex-like manner. In fact, repetitive actions like these take advantage of feedback loops through the spinal cord to make minute adjustments in muscle movements and to coordinate groups of muscles.

We are able to perform more than one activity at a time because the control of well-learned and rhythmic movements is transferred from the cerebrum to the cerebellum. The cerebellum already knows all of the instructions to send to the motor cortex. It has stored a "motor program." The thinking part of the brain no longer needs to be involved in supervising routine movements like walking, and thus becomes free to pay attention to other things.

In this activity, students will be able to experience the differences between well-learned voluntary movements and new movements.

## LINKS

This activity may be taught along with the following components of the Motor Highways unit:

### *Trouble at Tsavo* chapter:

Rumbling Thunder (see science box on page 22)

### *Explorations:*

Gray Matters (pages 2 and 3)

The Neuro Side (page 7)

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## ACTIVITY 6

### CONCEPTS

- Well-learned voluntary movements can be carried out almost without thinking about them.
- Programs for well-learned voluntary movements are stored in the cerebellum.

### OVERVIEW

Students will compare and contrast well-learned voluntary movements with new ones.

### SCIENCE & MATH SKILLS

Predicting, observing and drawing conclusions

### TIME

Preparation: 5 minutes

Class: 30 minutes

### MATERIALS

none needed



Cerebellum

The cerebellum stores "motor programs" for well-learned movements.

## SET-UP

Have students conduct this activity in pairs, as you direct the entire class.

## PROCEDURE

1. Ask the students to walk quietly next to their partners around the perimeter of the room (or any other designated short route). After a few moments, ask, *Did anyone have to stop and think about how to walk? Did you think about lifting and putting down one foot and then the other as you walked? Did you have to practice today before you could walk?*
2. Now, ask one member of each pair of students to tell a story or recite a poem to his or her partner as they walk together. Ask, *Was it difficult to walk and talk at the same time?*
3. Next, tell the walkers that they must walk in a straight line, putting one foot directly in front of the toe of the other. They should walk two steps forward and one step backward in this fashion. At the same time, have them tell the same story or poem to their partners while they perform this silly walk.
4. Ask, *Did you have to think about what you were doing as you walked? Could you talk at the same? Was it easy or hard? Would practicing make a difference?*
5. Lead a class discussion about the differences between the walking activities. Emphasize understanding that simple walking is a programmed motor pattern governed by the cerebellum. This allows the thinking part of the brain to do something else, such as concentrate on telling the story. Walking in a new way, however, is directed by the cerebrum—which makes it much harder to conduct another activity that also requires thinking at the same time. Ask, *Why do you think it is useful for us to have programmed motor patterns for some voluntary movements?*



Have students try practicing the "silly walk" over several days. Does it become easier for them to do? Are they finally able to talk or recite a poem and do the silly walk at the same time?

## BRAIN JOGGING

*Here is another idea for you and your students to explore.*

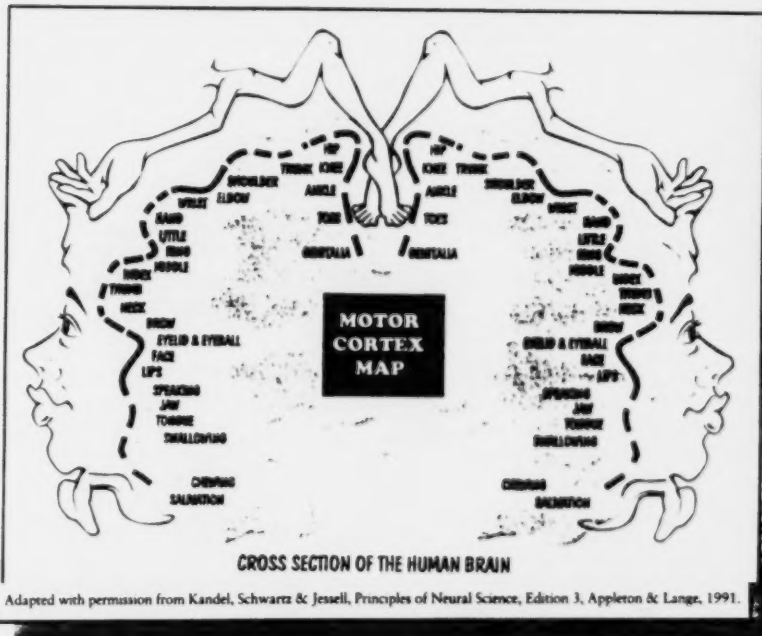
What situations can you think of in which it would be very important for you to be able to walk, run, ride a bicycle, etc., without having to pay attention to those movements? Write a short paragraph describing one of the scenarios.



## My Motor Strip

## BRAINLINK BACKGROUND (for the teacher)

Scientists have mapped the motor cortex of humans and other animals, and have identified the regions that are responsible for instructing each of the voluntary muscles of the body. They found that the more important a set of muscles is to a particular animal, the more space the control area for those muscles occupies on the motor cortex. By looking at a map of the motor cortex, such as the one given below, one can see which muscles are dominant. The motor cortex map for each animal is different, because each species uses different special movements depending on its habitat and lifestyle.



In this activity, students will construct a “headband” that shows the relative sizes and approximate positions of the main areas of muscle control on the motor cortex.

## LINKS

This activity may be taught along with the following components of the Motor Highways unit:

### Trouble at Tsavo chapters:

**Knee Jerk Reaction** (science box on voluntary and involuntary movement on page 29)

Also see science box on page 22

**Explorations:**

See Motor System drawing on page 3

## ACTIVITY 7

## CONCEPTS

- The motor cortex has specific areas that coordinate each group of muscles in the body.
- Important muscle groups occupy proportionately larger areas of the motor cortex.

## OVERVIEW

Students make a model of the motor cortex that they can wear, and they investigate which muscle groups correspond to the largest areas on the motor cortex.

## SCIENCE & MATH SKILLS

### Predicting, measuring, interpreting data and drawing conclusions

## TIME

**Preparation: 5 minutes**

**Class:** 45 minutes

## MATERIALS

- copies of "Motor Strip" on page 23 (one per student)
- pipe cleaners (one per student)
- tape measures or flexible rulers divided into millimeters (one per student or per group)

## SET-UP

Divide the class into small groups of 2-4 students to share materials. Each student will make a Motor Strip to wear.

## PROCEDURE

1. Tell students that they will be creating a model of the motor cortex—the part of the brain that directs muscles to carry out voluntary movements. Point out that all voluntary movements are directed through the motor cortex.
2. Have the materials managers pick up copies of the Motor Strip page, pipe cleaners and clear tape or glue for all members of their groups.
3. Explain that the areas marked on the Motor Strip represent the approximate lengths of motor cortex dedicated to controlling particular groups of muscles in the body. Larger areas of the motor cortex correspond to groups of muscles that are more important for human movement.
4. Have students measure the lengths of the areas (in mm) on the Motor Cortex strip corresponding to the hand and the elbow. Write the numbers on the board or make a bar graph to compare them. Ask, *Which area is longer? Which makes more complicated movements—your hand or your elbow?* Next, have them measure the areas corresponding to the lips and the forehead. Again ask them to identify which is longer and which area must make more kinds of movements. Help students understand that areas of the motor cortex that control complex and important muscle groups are larger than other areas of the motor cortex.
5. Find the longest bar on the Motor Strip. *Which part of the body corresponds to this bar?* Make a list of different movements that this body part can perform. Next, find the shortest bar and make a list of movements carried out by the corresponding part of the body.
6. Let students make their Motor Strips by following the instructions on the page.

## BRAIN JOGGING

*Here are more ideas for you and your students to explore.*

- Do you think that a cubic centimeter in the trunk of your body has the same number of motor neurons as a cubic centimeter of your hand? Why?
- The hand and individual fingers are represented by separate sections of the motor cortex. How much of the **total** length of the motor cortex is given over to controlling movement of the hands and fingers?



Students will make a model of the motor cortex that will sit approximately over the motor cortex area of the brain.

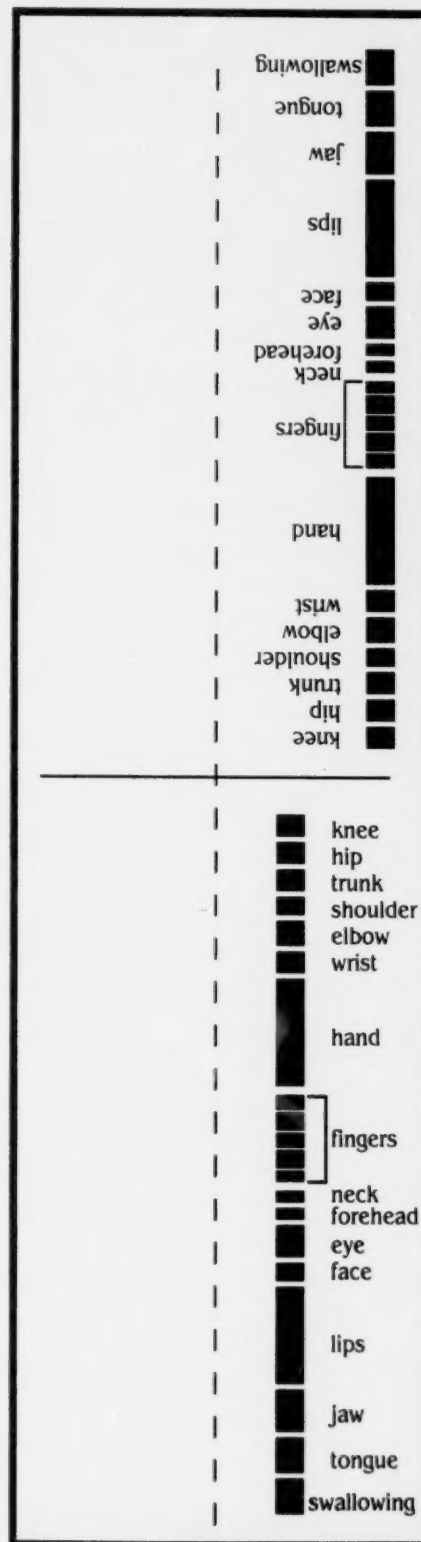
# Motor Strip

The motor cortex is a thin strip of nerve cells that sits across the top of the brain about where you would wear a set of headphones. Different parts of the motor cortex direct voluntary movement in different areas of the body.

You can see where the motor cortex of your brain is located by making a Motor Strip that you can wear. Each area of the strip will sit about where the actual area of motor cortex for these body parts is located in your brain.

1. Cut out the large rectangle on this page. This is the Motor Strip.
2. Fold the rectangle along the dotted line.
3. Put a pipe cleaner inside the folded rectangle, and close the edges of the sheet with glue or tape.
4. Bend the strip into a U-shape like a headband or headphones, and try it on.

Can you find about where your brain controls your fingers? Can you find where your brain controls your shoulder? Which area takes up more space on the motor cortex? Why do you think that this is so?



## Motor Model

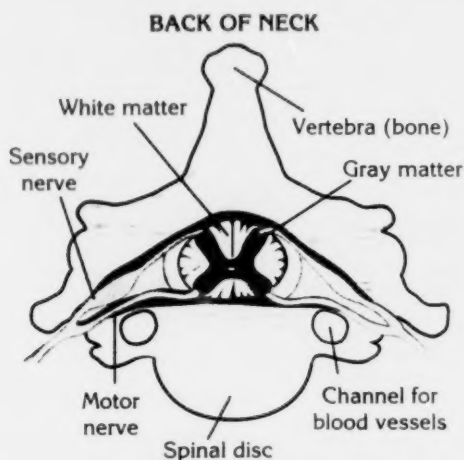
### BRAINLINK BACKGROUND (for the teacher)

Most movements are the result of finely tuned interactions between muscles and the nervous system. Movement can be initiated by the thinking part of the brain (cerebral cortex and associated areas) or it can represent an automatic response to information relayed along sensory neurons to the central nervous system. Generally, movements are classified as voluntary or involuntary, depending upon whether or not a conscious decision is made to initiate necessary muscle sequences.

The *central nervous system*, consisting of the brain and the spinal cord, is so important for survival that each element is protected by a bony structure. The brain is shielded by the cranium, as explored in the **Brain Comparisons** unit. The *spinal cord*, which consists mostly of nerve fibers, is protected by the spine or backbone. Unlike the cranium, the spine must allow for movement of the back and body, while maintaining its protective function. Consequently, it is comprised of a series of small bones called *vertebrae* (singular: vertebra). The flexible backbone distinguishes *vertebrates* from all other forms of animal life.

Nerve fibers extend from the spinal cord into other parts of the body through the gaps between vertebrae. Injury to a particular part of the spinal cord will affect communication to all parts of the body located below that point.

Medical specialists called *neurologists* frequently are able to localize specific areas of injury to the nervous system by observing which parts of the body have lost the capacity for



Cross section of spine and spinal cord

## ACTIVITY 8

### CONCEPTS

- The central nervous system helps to direct and coordinate movements.
- Damage to the spinal cord can affect the transmission of signals through the nervous system below the point of injury to the spinal cord.
- The backbone or spine protects the spinal cord.

### OVERVIEW

Students construct a model of the nervous system that highlights the most important structures involved in the control of movement.

### SCIENCE & MATH SKILLS

Measuring, modeling and drawing conclusions

### TIME

Preparation: 15 minutes  
Class: 45 minutes

### MATERIALS

Each student will need:

- copies of "Motor Model" and Motor Model Instructions (pages 27 and 28)
- play dough or Brain Dough (see instructions on p vi) in yellow, red and blue
- one paper clip
- one plastic drinking straw
- one 8½ x 11 inch sheet of cardboard or cardstock
- 12 inches (30 cm) each of two different colors of thin yarn or embroidery thread
- scissors
- clear tape
- white or craft glue
- colored markers with wide tips

movement. While damage to the spinal cord often will affect all of the body below the point of injury, damage to one side of the brain will sometimes affect only the opposite side of the body. This is because motor neurons leading from the brain to the spinal cord cross to the other side of the body in the brain or spinal cord region.

Motor neurons that start on the right side of the head cross to the left side of the spinal cord to control the left side of the body. Likewise, motor neurons originating in the left side of the brain cross to the right side of the body. Since our nervous system is "cross-wired," a physician might diagnose probable damage to the left side of the brain in an accident victim with motor and/or sensory loss on the right side of the body.

## LINKS

This activity may be taught along with the following components of the Brain Comparisons unit.

### *Trouble at Tsavo* chapters:

An Unexpected Flight  
Revisit science boxes on pages 5, 15 and 22

### *Explorations:*

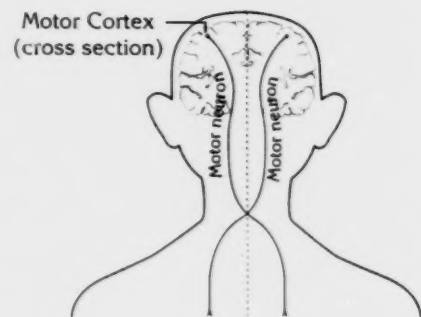
Gray Matters (pages 2 and 3)  
Spinal Cord Critter (page 5)  
Use Your Brain - Promote Your Health (page 4)

## SET-UP

Divide the class into small groups of 2-4 students to share materials as they each construct a Motor Model. Each student will need: 3 colors of play dough (a piece of yellow approximately 4 cm in diameter, and 2 cm each of red and blue), 1 paper clip, 1 straw, 12 inches of each color of yarn or thread, and copies of the Motor Model Instructions card and Motor Model page.

## PROCEDURE

1. Direct the students to glue or paste the copy of the "Motor Model" onto cardstock (unless you have made copies on cardstock).
2. Have each student construct a model of the three parts of the brain (cerebrum, cerebellum, brainstem) out of play dough. Give each student the correct amounts of each color, and have them create a yellow cerebrum, a red cerebellum, and a blue brainstem (colors correspond to those used for the same parts in *Brain Comparisons*). Show the students how to assemble the three parts into a model of the brain. Finished models should fit within the confines of the head on



Neurons for movement cross to the other side of the body



Human backbone



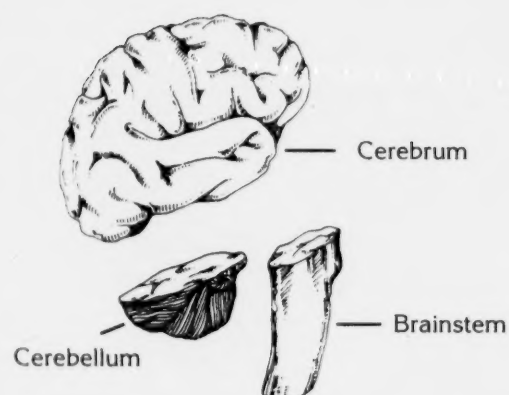
the Motor Model sheet. Review **Brain Comparisons** with the students if they have questions about the wrinkles and hemispheres of the cerebrum.

3. Demonstrate how to model the spinal column, using short pieces of straw for vertebrae, and thread or yarn for the nerve fibers going through the spinal cord. One color of thread should be used to represent motor neurons and another to represent sensory neurons. Detailed instructions are given on the Motor Highways Instruction Card. Have students work in pairs as they construct their models. If they have difficulty keeping the straw sections threaded, let them knot the free end of the "nerve fiber" threads around a pencil or paper clip. You may prefer to simplify the model for students by using only one color of thread or yarn.
4. When the students have completed their models, discuss how the brain communicates with muscles by way of spinal cord neurons. Point out the flexible nature of the straw "spine." Ask, *Why do you think this flexibility is necessary?*
5. Discuss the consequences of injury to the spinal cord. Ask, *What would happen to a person if his/her spinal cord were cut at the point that corresponds to right above the first straw "vertebra" in your model? What would happen if the spinal cord were cut or damaged between the third and fourth straw "vertebrae"?* If your students have read or are reading the Adventures component of this unit, *Trouble at Tsavo*, mention Shiloh Nimbus' paralysis. *How do you think this might have happened? Where on her spine do you think her injury occurred?*
6. Some of the students may know a person who is paralyzed on only one side of the body. Help them to understand that paralysis on one side may indicate some type of brain injury (trauma, stroke, tumor, etc.) on the opposite side of the brain ("cross-wiring"), while paralysis of both sides is more likely due to spinal cord injury.

## BRAIN JOGGING

*Here are more ideas for you and your students to explore.*

- Is it absolutely necessary for an animal to have a spinal cord? A backbone?
- Think of animals that have backbones. Are all of them capable of flexible movement? Are there any large animals without backbones? If so, where do they live?

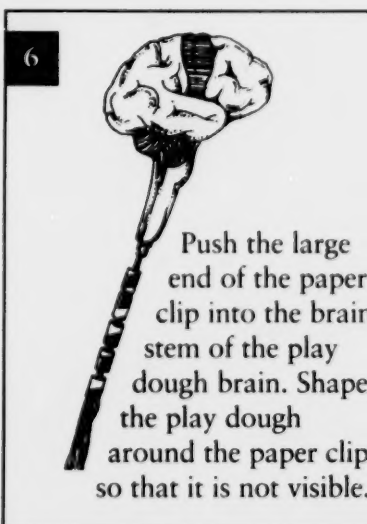
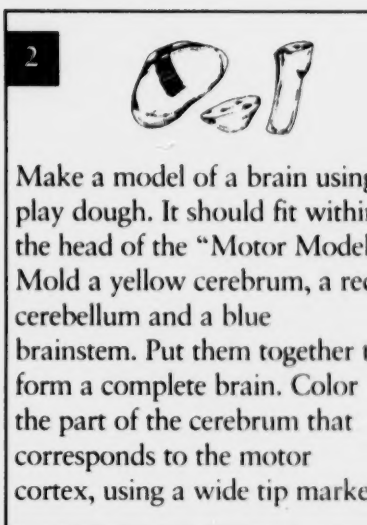
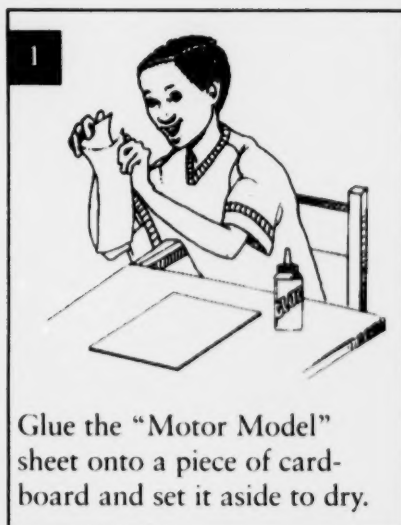


Parts of brain for Motor Model



Motor Model before nerve pairs have been pulled out between all vertebrae

## Motor Model



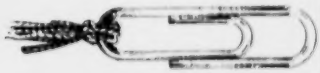
# Model Instructions

3



Using a pencil tip or paper clip, form the gyri in the cerebrum. Make a deep mark between the right and left hemispheres.

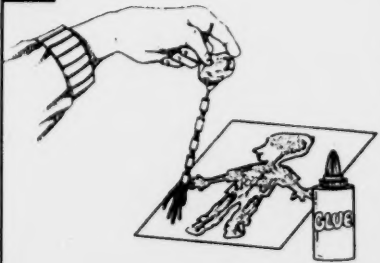
4



- Cut five pieces of straw about 1 cm ( $\frac{1}{2}$  inch) long.
- Cut 1 piece of yarn or thread about 30 cm (12 inches) long of each color (1 color for motor neurons, 1 color for sensory neurons).

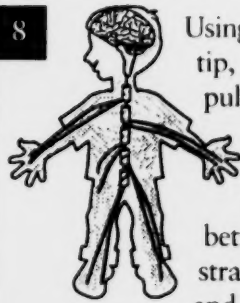
Tie both pieces of thread to the small end of a paper clip. Unravel each piece of thread into several strands.

7



With a partner, glue or tape the brain and spinal cord onto the "Motor Model" sheet.

8

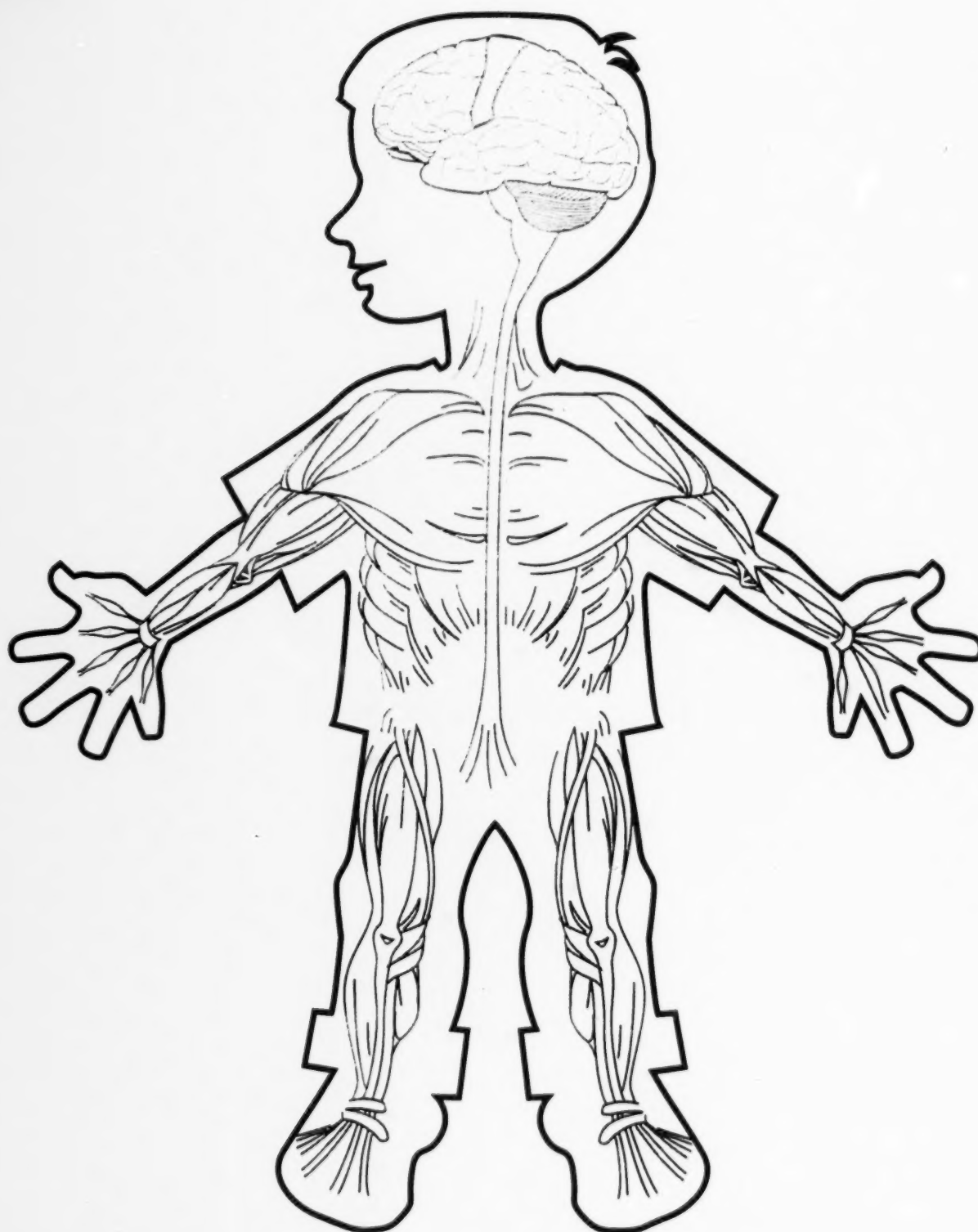


Using a pencil tip, carefully pull 1 strand of each color of thread out between the straw pieces and fasten the

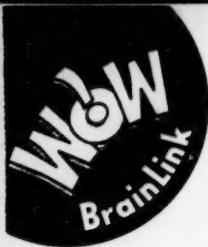
thread ends to muscles of the arms, legs, or body of the "Motor Model." Trim the threads if they are too long.



## Motor Model



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## Moving Biographies

### BRAINLINK BACKGROUND (for the teacher)

In motor system diseases, the neuron pathways that control movement are disrupted. This can result from damage to portions of motor neurons or from the death of whole neurons. Perhaps the most well-known motor system diseases are *polio*, *amyotrophic lateral sclerosis* (ALS) and *multiple sclerosis* (MS).

Many motor system diseases progress gradually. In the beginning, affected persons often notice weakness in a particular part of the body, or find that they are becoming clumsy or that they tire more easily. It may be more difficult for them to speak clearly because the muscles controlling speech have been affected. Weakness occurs because the muscles no longer receive orders to move. In many cases, weakness progresses to complete paralysis as more motor neurons become damaged.

Right now there are no cures for motor system diseases. Once a neuron is destroyed, the nervous system is not able to replace it. Some motor system diseases can be prevented. Polio, a disease caused by a virus that destroys neurons, once affected thousands of children every year. Now everyone can be vaccinated to protect against this disease. For other motor system diseases, like multiple sclerosis, the initial causes still are not known, so there is no known way to prevent them. In these cases, the only way to help the patient is to try to slow down the progression of the disease once it has started. The search for effective treatments is an active and exciting area of research in neuroscience.

It is important to remember that the ability to move is the primary loss with most of these diseases. People with ALS and polio do not lose input from the senses or the ability to think. Multiple sclerosis, on the other hand, affects movement and also can affect sensory pathways and the thinking part of the brain.

People with motor system diseases often are able to continue to work creatively throughout their lives. Many of them, like the people profiled in this activity, have contributed and will continue to contribute great things to society.

## ACTIVITY 9

### CONCEPTS

- Neuron pathways that control movement are disrupted in motor system diseases.
- People with motor system diseases often are able to lead productive lives.

### OVERVIEW

Readings about four famous people with different motor system diseases are provided to stimulate discussion and further exploration.

### SCIENCE & MATH SKILLS

(Using resources to gather information, drawing and presenting conclusions and supporting information)

### TIME

**Preparation:** 5 minutes  
**Class:** 45 minutes (additional class periods will be necessary if students gather additional information and report back to the class)

### MATERIALS

- copies of "Scope It Out" and "Moving Biographies" (pages 31-35)

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## LINKS

This activity may be taught along with the following components of the Motor Highways unit.

### **Trouble at Tsavo chapters:**

New Beginnings (see science box on page 32)

### **Explorations:**

Decade of the Brain (page 4)

Use Your Brain—Promote Your Health (page 4)

Careers for NeuroExplorers (page 7)

## SET-UP

Conduct this activity with the entire class. Students or groups can be assigned readings and then asked to find further information, either about the individuals or the diseases, from the library or from the suggested source organizations.

## PROCEDURE

We have selected four of many people who have experienced motor system diseases. The black-line master "Scope It Out!" provides other sources of information for students.

1. Ask the students if they have heard of Barbara Jordan, Franklin Delano Roosevelt, Stephen Hawking or Lou Gehrig. Discuss what the students already know about each of these famous individuals.
2. Tell them that these persons have something in common. Ask them if they can guess what it is.
3. Distribute the readings and use them in whatever way you think best. You might divide the class into four groups and assign one of the readings to each group. Let the members of each group read, share and discuss their reading, and report their findings to the class.
4. Encourage students to learn more about motor system diseases by studying these people or others (including people they may know) with such diseases.

## BRAIN JOGGING

*Here are more ideas for you and your students to explore.*

- Write a short story or diary from the point of view of a person who has a motor system disease.
- If you were a new kid at your school who had a motor system disease and had to use a wheelchair or braces, what would you tell your friends about your disease?



Barbara Jordan, Franklin Delano Roosevelt and Lou Gehrig all had diseases of the motor system.

## Scope It Out!

People of all ages and with different careers have motor system diseases. Maybe you know someone with this kind of disease. Scientists are trying to find cures or ways to prevent these diseases. Here are a few persons whom you or your parents may have heard about. See what other information you can discover about them or their diseases. Perhaps the organizations listed below can give you some help.

### Famous People

Donna Fargo (singer who has MS)  
Annette Funicello (actress who has MS)  
Judy Holliday (actress who had Polio)  
Jacob Javits (senator who had ALS)  
Ida Lupino (actress who had Polio)  
David Niven (actor who had ALS)  
Richard Pryor (comedian who has MS)

### Scientists

Albert Sabin (Polio vaccine researcher)  
Jonas Salk (Polio vaccine researcher)

### Organizations\*

American Academy of Neurology  
2221 University Avenue SE  
Suite 335  
Minneapolis, MN 55414

ALS Association  
21021 Ventura Boulevard  
Suite 321  
Woodland Hills, CA 91364

March of Dimes Birth Defects Foundation  
1275 Mamaroneck Avenue  
White Plains, NY 10605

National Multiple Sclerosis Society  
205 East 42nd Street  
New York, NY 10017

\* Large cities may have local chapters of these organizations.



Stephen Hawking

## A Courageous Congresswoman

Barbara Charline Jordan was born in 1936. She grew up in a nice, neat house in a poor area of Houston, Texas. Her parents taught her the value of study and hard work. Her father, a Baptist minister, told her she could do anything if she worked hard enough. Barbara listened. She made it through high school, college and law school, to become a lawyer by the age of 24.

Barbara knew that she wanted to help change the way America was governed. She wanted to make things better for all people. She saw that she might be able to do this by going into politics. She worked for changes that helped lead to the Civil Rights Act. President Lyndon Baines Johnson signed this act into law in 1964. It made certain that the laws of the country would be equal for everyone.

In 1967, Ms. Jordan became the first African-American woman elected to the Texas Legislature. Five years later, she became the first African-American woman from the South ever elected to the U.S. House of Representatives (part of the U.S Congress). There she worked very hard to do things that would help people.

After serving six years in the U.S. Congress, she retired in 1978 from elected office. She became a teacher at the Lyndon Baines Johnson School of Public Affairs at the University of Texas. She was a very popular and inspiring teacher. Everyone wanted to be in her classes.

When Barbara Jordan left the U.S. Congress, she was having trouble walking. By the time she began teaching in 1979, she was in a wheelchair. Professor Jordan had multiple sclerosis.

Multiple sclerosis (sklah-RO-sis) (MS for short) is a disease that breaks down the covering that protects many neurons. This covering, called myelin (MY-uh-lin), helps to conduct messages through the body. When myelin is destroyed it is replaced by scars. (Multiple sclerosis means "many scars.") Messages cannot travel along the neurons, so messages from the brain that tell the body to move do not get through.

The spinal cord is one place where the scars often are found. They cause weakness and stiffness of the legs and arms. They can cause numbness in these limbs, like the tingling you feel when your leg or foot goes to sleep. MS affects each person who has it differently. It is a condition that is likely to last a person's lifetime.

MS may have played a part in Professor Jordan's decision to leave the U.S. Congress. It certainly did not keep her from being an outstanding teacher. She was greatly respected for what she accomplished. People throughout the nation will always remember her words of wisdom and her leadership.





## FDR and the Fight to Prevent Polio

James Roosevelt snapped his father's leg braces into place. Using crutches, Mr. Roosevelt walked slowly to the platform. His son, James, was at his side. The crowd grew silent. Franklin Delano Roosevelt, known as FDR, began his speech. He was the respected Governor of New York, and he was nominating someone for the presidency of the United States. People would remember his speech, and they would remember FDR.

As a young man, Roosevelt had caught the virus that causes polio. Polio is a disease that can spread from one person to another. Long ago, polio killed or paralyzed many people, mostly children.

When the polio virus reaches the brain and spinal cord, it destroys nerve cells. When the nerve cells are destroyed, messages that normally would travel to and from the brain along the spinal cord cannot reach the muscles. Arms and legs cannot move. The most serious kind of polio results when the virus attacks the nerve cells in the brainstem or the spinal cord that control breathing. When this happens, the person cannot breathe without the help of a machine.

Although his legs were paralyzed and could not move, FDR exercised to strengthen other muscles in his body. These muscles could help support his legs. Over time, his control improved until he only needed braces for his lower legs and knees. Having polio did not keep FDR from facing his future. He, himself, was nominated for the presidency. He became the 32nd President of the United States!

One of the many important things FDR did as President was to help form a group of people to stop the spread of polio. This group formed an organization called the March of Dimes. During the Great Depression of the 1930s, many people in America were very poor. Even so, they sent their dimes to the March of Dimes to help find a cure or treatment for polio. Some of this money went to scientists who studied polio. It was through scientific study that Dr. Jonas Salk was able to make the first vaccine, a shot to prevent polio.

The vaccine against polio was first used in the early 1950s. Since that time, children in America and the rest of the world get vaccines that protect them from polio. These vaccines help the human body develop defenses, called antibodies, against the germs that cause polio. That is why you do not hear very much about people having polio today.

Vaccines against polio and other infectious diseases like measles, mumps, and the flu have saved the lives of millions of children and adults.



## Exploring Space from a Wheelchair

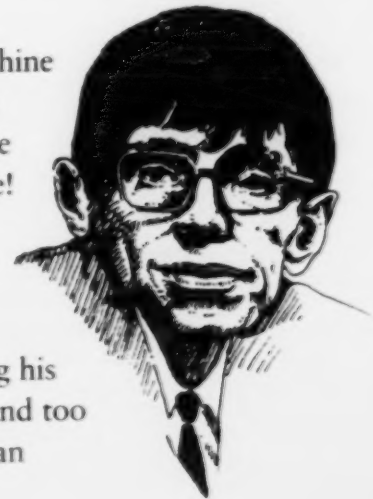
Stephen W. Hawking is no ordinary man. He is one of the greatest thinkers of our time. His mind has explored distant galaxies and black holes. He has asked the questions, "Was there a beginning of time? Will there be an end? Is the universe boundless?" His search for answers has brought us closer to the secrets of time, space and the universe. Remarkably, he has done all of these things for more than twenty-five years from a wheelchair.

Professor Hawking has motor neuron disease, or amyotrophic lateral sclerosis – ALS for short. It also is known as "Lou Gehrig's disease" after the famous baseball player who also had ALS. The word "amyotrophic" (a-my-o-TRO-fik) means a withering or weakening of muscles. Lateral means "to the side" and sclerosis (sklah-RO-sis) means "scar." So together, these words mean muscle weakening that is caused by scarring in the lateral (side) part of the spinal cord (which contains critical motor pathways).

ALS destroys the motor nerve cells (neurons) in the nervous system that directly control the muscles. Without motor neurons there is no way for the brain and spinal cord to get messages out to the muscles. It is as if the wire between two telephones had been cut. There is no pathway to get a message through. Right now, doctors do not have a cure for this disease, but many people are working to discover one.

ALS may prevent a person from moving, but it does not damage a person's thinking. Professor Hawking, for example, has an active mind and, from his wheelchair, is helping us understand how the universe works. When he caught pneumonia in 1985, he had to have an operation that took away his ability to speak. Yet it has not stopped him from communicating.

With the help of a small computer, a voice synthesizer (a machine that makes speech sounds), his friends and health care givers, he continues to tell the world about the physical universe. In fact, he says that he can communicate better than before he lost his voice! In spite of the challenges of living with ALS, Dr. Hawking does not view it as a serious handicap. He says he was lucky to have chosen a career that is "all in the mind."



He does have one complaint. In a recent radio interview using his voice synthesizer, he complained that the machine made him sound too much like an American. Professor Hawking is very proud to be an Englishman!

## The Iron Horse

Crack! Lou Gehrig hit the baseball right out of the field. It was the fourth home run that he would hit on that day in 1932. Lou Gehrig was famous for hitting home runs. He played for the New York Yankees for twelve years.

Lou Gehrig was born in New York City in 1903. His parents had come from Germany and moved to a poor neighborhood. Lou often had to work at odd jobs to help earn money for his family, but his mother insisted that he finish high school. She also encouraged him to attend Columbia University, where he played both football and baseball. He finally became a professional ballplayer in 1923.

One of his teammates was another famous baseball player named Babe Ruth. Together they helped the Yankees win many games.

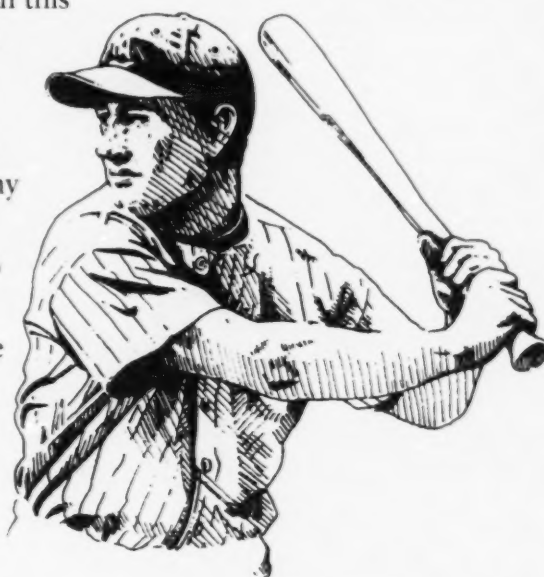
Lou Gehrig was a very strong and reliable player. He played in over 2,000 games in a row for the Yankees. His nickname was the "Iron Horse," because he never missed a game.

After he had played baseball for many years, Lou Gehrig became mysteriously weak. He would stumble and sometimes had difficulty throwing or catching the baseball. His weakness was puzzling to his teammates. Finally, the doctors at the famous Mayo Clinic in Minnesota diagnosed his strange illness. He had amyotrophic (a-my-o-TRO-fik) lateral sclerosis (sklah-RO-sis), also known as ALS.

ALS destroys motor neurons in the spine. They become scarred and can no longer carry messages from the brain to the muscles. Persons with this disease suffer a gradual weakening of their muscles.

Lou Gehrig had many fans. He was one of the most popular baseball players of all time. When he decided to retire from baseball because of ALS, many people attended the ceremony. More than 60,000 fans gathered in Yankee Stadium on July 4, 1939 to wish him well. Lou Gehrig was very happy to be with his fans. He said, "Today, I consider myself the luckiest man on the face of the earth."

Lou Gehrig helped focus public attention on ALS. Many people admired his brave struggle against the progression of the illness. That is why ALS sometimes is called "Lou Gehrig's disease."



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## NeuroKids

### BRAINLINK BACKGROUND (for the teacher)

Most movements are the result of finely tuned interactions between muscles and the nervous system. Movement can be initiated by the thinking part of the brain (cerebral cortex and associated areas) or it can represent an automatic response to information relayed along sensory neurons to the central nervous system. Generally, movements are classified as voluntary or involuntary, depending upon whether a conscious decision is made to initiate the necessary muscle sequences.

*Involuntary movements* are those that are initiated without any thought or concentration. Some involuntary movements keep the body running smoothly. Others, called reflexes, occur as a direct response to changes in conditions (inside or outside the body). Reflexes follow very simple pathways that do not include the thinking part of the brain in the path between sensory input and motor output. As a result, the reaction time for reflexes is relatively short.

*Voluntary movements* are those that are undertaken "on purpose." Voluntary movements are controlled by a particular part of the cerebrum: the motor cortex. As voluntary movements are practiced, they become easier to perform. Control of such movements is gradually passed to the cerebellum. Eventually, very well learned voluntary movements become almost automatic, but they still are directed by the brain.

### LINKS

This activity may be taught along with the following components of the Motor Highways unit.

#### *Trouble at Tsavo chapters:*

Review science boxes throughout

#### *Explorations:*

Cover activity

Gray Matters (pages 2 and 3)

### SET-UP

Divide the class into small groups of 2-4 students to share materials as each group constructs a NeuroKid. Each group will work independently to produce a graphic model of a nervous system pathway. This activity can be used to assess understanding of basic concepts covered in the Motor Highways unit.

The production of one or more NeuroKids also may be undertaken as a whole class activity, with the teacher providing direct guidance.

## ACTIVITY 10

### CONCEPTS

- Motor systems concepts presented in preceding activities are reviewed.

### OVERVIEW

Students work in small groups to produce life-size diagrams (NeuroKids) of the pathways followed by nervous system signals for reflexes and voluntary movements.

### SCIENCE & MATH SKILLS

Modeling, problem solving and applying prior knowledge to new situations.

### TIME

**Preparation:** 15 minutes

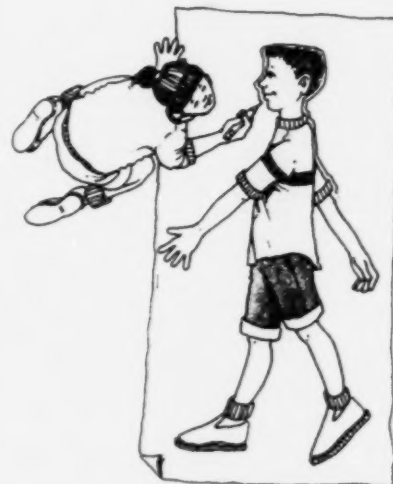
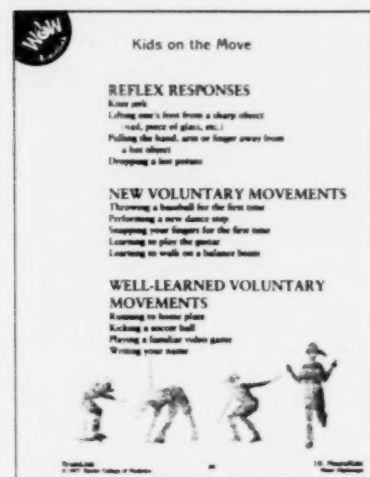
**Class:** 45-60 minutes in one or two sessions

### MATERIALS

- overhead or copies of "Kids on the Move" on page 39
- 1.5 to 2 meter sheets of wide paper (one large sheet per group)
- markers or crayons (several colors)

## PROCEDURE

1. Review pathways for reflexes and voluntary movements using the students' Motor Models or the NeuroKid pages. Encourage students to suggest different examples of involuntary and voluntary movements.
2. Tell students that they will produce lifesize drawings of the pathways followed by signals in the nervous system for movement. Show the list of possible movements provided on the Kids on the Move page. Ask each group of students to decide which movement they would like to represent in their life-size drawing. Groups also may illustrate a movement that does not appear in the list. Be sure that, among the groups, at least one reflex response, one new voluntary movement and one well-learned voluntary movement are included.
3. Have each group spread a large sheet of paper on the floor. One student in each group will serve as the model by lying on the paper. One or more other students will trace the model's outline in pencil. The student serving as the model should assume a position appropriate to the movement being illustrated. After the pencil outline is complete, have the students adjust irregularities in the profile as they trace over the pencil lines with a black marker.
4. Have the members of each group draw the central nervous system (brain—showing cerebrum, cerebellum, brainstem and motor cortex—and spinal cord) on their NeuroKid outline.
5. Ask the members of each group to think about the nervous system pathways that will be followed when the movement that they have selected is carried out. After they have decided on the pathways, have them color the following parts of the nervous system involved in movement as described below.
  - *Place where sequence begins.* Reflexes begin at the point of sensory stimulus (hand, foot or knee, for example). Other movements begin in the cerebrum (representing the decision to "move").
  - *Pathway from place where movement begins to appropriate level in the spinal cord.* In a reflex response, the pathway will lead from the arm or leg to the spinal cord. In a new voluntary movement, the pathway will lead from the cerebrum where the thought begins to the motor cortex, through the brainstem and into the spinal cord. For a well-learned voluntary movement, the pathway will lead from the cerebrum to the cerebellum before passing to the motor cortex.



Have one student in each group serve as a model.

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- *Pathway from spinal cord to muscle(s) involved in the movement.*
  - *Pathway back to brain from muscles or spinal cord.*
6. Encourage students to use their imaginations and add names, props or other decorations to their NeuroKids.
  7. Have each group present and describe its NeuroKid to the rest of the class. Encourage students to think about the pathways being followed by asking questions: *Is this an example of a voluntary or an involuntary movement? Would this movement improve with practice? How is this movement different from the movement presented by the previous group?*

## BRAIN JOGGING

*Here are more ideas for you and your students to explore.*

- Coughing usually is a reflex response. Chewing is a well-learned voluntary movement or habit. In what ways are coughing and chewing similar? In what ways are coughing and chewing different?
- The “knee jerk” is an example of a reflex response. Can you move your leg in the same way as a knee jerk by just deciding to do it? Was your voluntary leg movement identical to the knee jerk? Why or why not?
- We often do not think about the small movements that are part of a very well-learned voluntary activity that has become automatic. Try to describe in detail how you carry out a routine activity such as tying your shoes or buttoning your shirt.

## Kids on the Move

### REFLEX RESPONSES

Knee jerk

Lifting one's foot from a sharp object  
(nail, piece of glass, etc.)

Pulling the hand, arm or finger away from  
a hot object

Dropping a hot potato

### NEW VOLUNTARY MOVEMENTS

Throwing a baseball for the first time

Performing a new dance step

Snapping your fingers for the first time

Learning to play the guitar

Learning to walk on a balance beam

### WELL-LEARNED VOLUNTARY MOVEMENTS

Running to home plate

Kicking a soccer ball

Playing a familiar video game

Writing your name



# Glossary

**amyotrophic lateral sclerosis** - nervous system disease that destroys motor neurons and results in a loss of muscle control

**axon** - tail-like branch of a neuron along which messages are transported in the nervous system

**brain** - the control center of the nervous system, located within the skull and attached to the spinal cord; the command center of the body

**brainstem or brain stem** - structure that connects the rest of the brain to the spinal cord and controls basic survival activities such as breathing, heartbeat, body temperature, and digestion

**central nervous system** - the part of the nervous system in vertebrates that consists of the brain and spinal cord

**cerebellum** - part of the brain located directly above the brainstem that controls the sense of balance and helps the muscles work together for learning and coordination of rote movements

**cerebral cortex** - the outermost component of the brain's cerebrum; controls our most advanced abilities, such as speech and reasoning

**cerebrum** - the large, rounded outer layer of the brain where thinking and learning occur, sensory input is received and voluntary movement is started

**dendrite** - one of many tree-like branches extending from the body of a neuron on which signals are received

**gray matter** - nervous system tissue that is composed primarily of cell bodies and nerve fibers without a myelin sheath

**involuntary movement** - movements that are started without any thought or concentration—that happen without any input from the cerebrum

**motor cortex** - the region of the cerebrum responsible for starting and controlling voluntary movement, located in a narrow strip across the top of the brain

**motor neuron** - a type of nervous system cell, originating in the brain or spinal cord, that conducts signals to muscles, resulting in movement

**multiple sclerosis** - nervous system disease in which the myelin sheath covering nerve fibers is broken down—results in a gradual weakening of the muscles

**muscle** - body tissue consisting of long cells that contract when stimulated and produce motion

**myelin** - fatty substance that forms a thick sheath around the axons of some nerve cells

**nerve** - a bundle of nerve fibers and associated cells

**nerve fiber** - any of the branches of a neuron including dendrites and axons

**neurologist** - a medical doctor specializing in the diagnosis and treatment of disease and injury in the nervous system

**neuron** - a cell of the nervous system that conducts a signal from one part of the body to another

**peripheral nervous system** - part of the nervous system that is outside of the brain and spinal cord

**polio** - infectious nervous system disease caused by a virus that affects nerve cells in the brain or spinal cord and leads to loss of motor function

**reflex** - an involuntary motor response to a sensory stimulus, often for the purpose of protection

**reflex arc** - the complete nervous path that is involved in a reflex, usually consisting of detection of a stimulus by sensory neurons, communication with motor neurons in the spinal cord or brainstem, and stimulation of muscles by motor neurons

**sensory neuron** - a type of nervous system cell that transmits impulses from a sense organ toward the central nervous system

**spinal cord** - bundle of nerve fibers that runs inside the spine

**spine** - a series of connected bones along the back of a skeleton, also known as the backbone

**synapse** - tiny gap between the axon of one neuron and the cell body or dendrite of another neuron across which messages are transmitted chemically or electrically

**synapse firing** - chemical or electrical transmission of signals from one neuron to another across a synapse

**vertebra** - any of the bony segments that make up the spine (plural: vertebrae)

**vertebrate** - animal that has a spine

**voluntary movement** - movement that is done on purpose or involves a choice; always requires input from the cerebrum

**white matter** - nervous system tissue that is made up of nerve fibers covered with a myelin sheath





BrainLink® Activities  
Developed by  
Baylor College of Medicine  
Houston, Texas  
ISBN 1-888997-22-2

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# THE READING LINK

Reading activities to use with

## TROUBLE AT TSAVO

The NeuroExplorers in



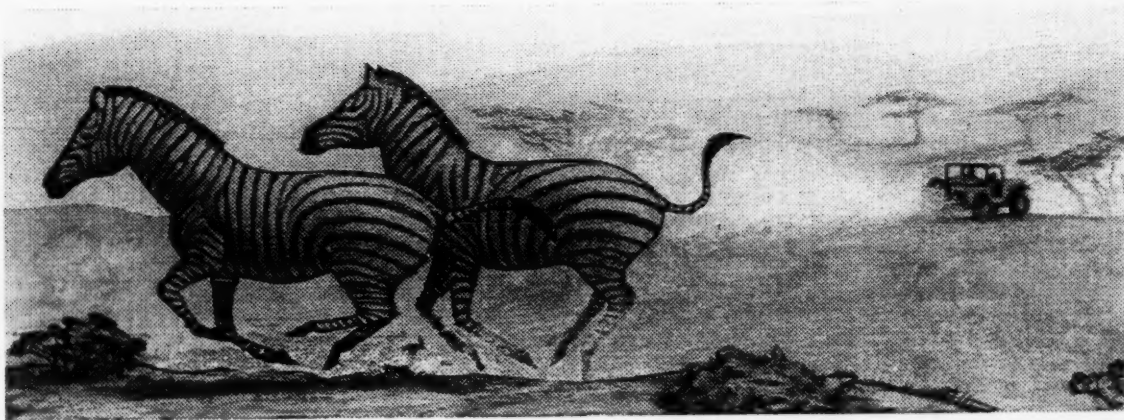
### The Tale of the Black Rhino

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**BrainLink® : Motor Highways**

The Reading Links have been created as ready-to-use reading and writing activities that are directly related to BrainLink adventure stories. They are not intended to represent a comprehensive reading program. The activities are related to reading objectives common to many curricula and covering a range of grade and ability levels. Teachers may wish to select from these activities those that are most appropriate for their own students.

*Prepared by*  
Baylor College of Medicine  
Houston, Texas  
1997



### Word Meanings

Here are some words from *Trouble at Tsavo* that have more than one meaning. Look at the meanings for each word, and then decide which meaning goes with the word in each of the sentences. Write the number of the correct meaning next to each sentence.

#### preserve

1. to protect; keep safe from injury or destruction
2. an area maintained for the protection of wildlife or natural resources
3. fruit cooked with sugar and canned for future use; jam or jelly
4. to protect food from spoiling, as by freezing, canning or pickling

- \_\_\_\_\_ Hunting is not allowed in the wildlife preserve.
- \_\_\_\_\_ We're going to preserve the cucumbers in our garden by making pickles.
- \_\_\_\_\_ We must preserve our forests.
- \_\_\_\_\_ Please pass the raspberry preserves.

#### crest

1. the top part of something, as of a mountain or a wave
2. a coat of arms, or the prominent design at the top of a coat of arms
3. a tuft of feathers growing on the top of an animal's head, as on a bird
4. a plume (usually feathers) on a knight's helmet

- \_\_\_\_\_ The family crest hung over the fireplace in the great hall of the castle.
- \_\_\_\_\_ Can you see the crest on that bluejay's head?
- \_\_\_\_\_ When I reached the crest of the hill, I could see the river below.
- \_\_\_\_\_ The Black Knight's crest waved in the wind, as he galloped toward his opponent.



Here are the definitions of some words used in *Trouble at Tsavo*. Write a sentence using each word. Your sentences should tell something about the story.

1. **poacher** - one who hunts or kills game or fish illegally
2. **inflammation** - a red and painful swelling caused by injury or infection
3. **involuntary** - not voluntary; something that happens without thought or control
4. **paralysis** - loss of the ability to move
5. **terrain** - features of a particular area of land
6. **potent** - strong; powerful and effective

1. \_\_\_\_\_

2. \_\_\_\_\_

3. \_\_\_\_\_

4. \_\_\_\_\_

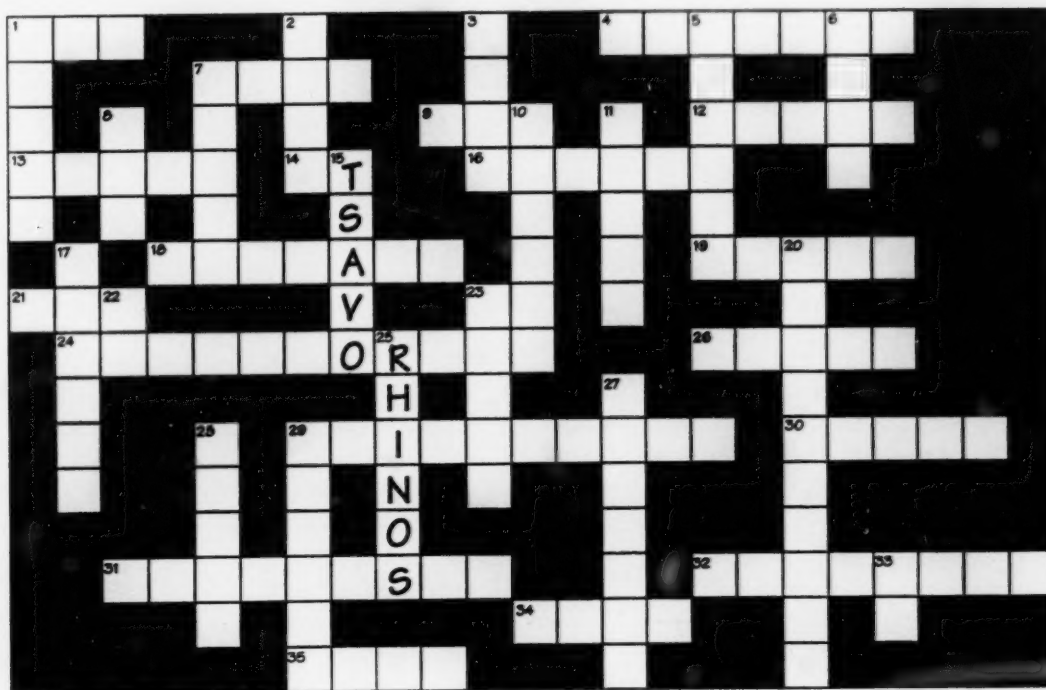
5. \_\_\_\_\_

6. \_\_\_\_\_



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Trouble at Tsavo Crossword Puzzle



ACROSS

1. Weight measure suitable for rhinos
4. When a kind of animal no longer exists, it is \_\_\_\_\_.
7. Patellar reflex: \_\_\_\_\_-jerk
9. Fasten your seat belt when you get into the \_\_\_\_\_.
12. Bundle of neuron fibers
13. One of the NeuroExplorers is called  
The \_\_\_\_\_.
14. Initials for title of this book
16. Nervous system cell that carries messages
18. Dead body of an animal
19. Motor cortex: \_\_\_\_\_ of brain under your  
headphones
21. B.J. \_\_\_\_\_ the table with her drumstick.
23. Pronoun for myself
24. Part of the brain you use when you choose to move  
(2 words)
26. Another kind of rhinoceros
29. Nerve bunches inside the bony spine (2 words)
30. Kyle called the NeuroExplorers meeting to \_\_\_\_\_.
31. Loss of the ability to move
32. Wrinkled part of the brain, where thinking occurs
34. Vehicle used in the desert
35. Part of the rhino wanted by poachers

DOWN

1. Group of people; there are some in Africa
2. Shiloh forgot to fasten her seat-\_\_\_\_\_.
3. Shiloh's \_\_\_\_\_ was to return to Africa.
5. Sport played by Shiloh
6. Location of the NeuroExplorers' last adventure
7. Country in Africa where Shiloh went
8. One of the NeuroExplorers
10. An involuntary motor response
11. Shiloh's Dad slammed on the \_\_\_\_\_.
15. Plains where Shiloh's adventure took place
17. Shiloh's Dad: Dr. \_\_\_\_\_
20. Large African animal with horn
22. In a direction toward
23. A jeep is made mostly of \_\_\_\_\_.
25. Three of these charged the jeep
27. One who takes or kills animals illegally
28. Striped African animal
29. Heroine of this story
33. Drumming NeuroExplorer

Details/Supporting Ideas

At the beginning of the story, *Trouble at Tsavo*, the NeuroExplorers watched a tennis game. From your memory, describe what they saw. Include as many details as you can.

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What clues did Shiloh's Dad use to identify the skulls he found in Africa?

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Main Idea

Read the yellow Science Box on page 5. Fill in the circle next to the sentence that best expresses the main idea of that paragraph.

- ☐ When we move, muscles and the nervous system must work together.
- ☐ Signals for movement start in the brain or spinal cord.
- ☐ The messages are carried along special cells, called neurons, to the muscles.
- ☐ When the spinal cord or other parts of the nervous system are damaged, messages can't get through.

Write one sentence that tells the main idea of the story, *Trouble at Tsavo*.

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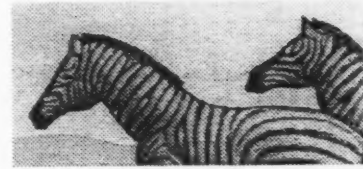
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### Summary of a Selection

Kyle's cousin, Sue, is interested in exotic animals and wants to go on an African safari some day. Pretend that you are Kyle. Write a letter to Sue, telling her about Shiloh's adventures in Africa.



Explain briefly why Shiloh cannot move her legs. (Give the physical, or medical, explanation.)



### Recalling Sequence of Events

Read the chapter called "A Spinal Cord Puzzle" on pages 11 - 13. Find the event listed below that happened **last** in that chapter. Mark 5 next to it. Then number the order (1 - 4) in which the other events happened.

- \_\_\_\_\_ Shiloh explained the difference between paraplegia and quadriplegia.
- \_\_\_\_\_ Shiloh Nimbus knew that she had found some great new friends.
- \_\_\_\_\_ The NeuroExplorers used charts and models to review what they knew about the spinal cord and movement.
- \_\_\_\_\_ Isley II interrupted Shiloh's story of her adventures in Africa.
- \_\_\_\_\_ The NeuroExplorers admitted their surprise at Shiloh's ability to play tennis.



After you have read the whole story, number the order in which the following events took place.

- \_\_\_\_\_ Shiloh called the game warden for help against the angry poachers.
- \_\_\_\_\_ Shiloh played an intense game of tennis.
- \_\_\_\_\_ Shiloh and her father spotted three rhinos in the distance at a watering hole.
- \_\_\_\_\_ Dr. Nimbus' jeep went flying above a ravine, and Shiloh flew out.
- \_\_\_\_\_ Shiloh stood on her seat in the jeep and used her binoculars to look for birds.



**Cause and Effect**

Name at least 3 different things that caused Shiloh to be badly injured.

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What is the effect of people's willingness to pay a lot of money for black rhinos' horns?  
Explain what first happens, and then tell the long-term effect.

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Point of View/Fact-Opinion

Facts are true. Opinions sometimes are stated as facts, but they might not be true. Decide whether each of these statements related to the story is a fact or an opinion. Write F or O in each space.

- \_\_\_\_\_ Shiloh's father loves the big animals in Kenya. (pg. 7)
- \_\_\_\_\_ The black rhinoceros is a majestic creature. (pg. 5)
- \_\_\_\_\_ Neurons should be able to heal, just like skin and bones do. (pg. 15)
- \_\_\_\_\_ Poachers could take rhinos' horns and still let the rhinos live. (pg. 18)
- \_\_\_\_\_ Black rhinos are almost extinct. (pg. 18)
- \_\_\_\_\_ Shiloh and her father should go after the poachers. (pg. 18)
- \_\_\_\_\_ Reflexes happen so fast because they don't involve the thinking part of the brain. (pg. 29)



**Inference/Generalization/Drawing Conclusions**

Which of the following generalizations or conclusions can be made from the information given in the story, *Trouble at Tsavo*? Fill in the circle next to each statement that you think is correct.

- ☐ Getting to know someone with a disability really opened the eyes of the NeuroExplorers and helped them to understand some "neuro-" questions.
- ☐ It is important to wear a seat belt when riding in a car or truck.
- ☐ Poachers don't care about the results of their actions.
- ☐ The damage to Shiloh's spinal cord was near her neck.
- ☐ Both the brain and the spinal cord are important for movement.
- ☐ Kenya should raise more black rhinos so that there will be enough of the medicine that comes from their horns.
- ☐ Shiloh is a talented story teller.
- ☐ Shiloh is very depressed about being in a wheelchair and doesn't see any hope for herself.





Shiloh and her father plan to go back to Africa to start a new population of black rhinos in a safer place. Think of all the possible reasons the government might want to protect animals. Why would they want to keep animals from becoming extinct? What impact could the extinction of a particular animal have on people or other living things?

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Think about what might happen after the end of this story. For instance, will Shiloh and her father return to Africa? What will happen there? Will Shiloh remain friends with the NeuroExplorers? Write your predictions.

What do you think Shiloh's life will be like? What will she do during the rest of her years in school? What successes or what problems will she have? What will she be when she grows up? Write about your predictions.

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

### Painting Pictures with Words

Sometimes words are used in an unusual way to help us understand what is being described. For example, someone might say, "He was as happy as a child in a candy store." This is called a simile (*sihm-uh-lee*): A simile is a figure of speech that uses the words "like" or "as" to compare two things that are unlike. However, the words paint a very clear picture for us.



Look at these word picture sentences from *Trouble at Tsavo*. Then see if you can write sentences of your own, using similes. You might describe a desert scene or charging beasts in Africa, or the action or feelings of a character, or whatever you like.

#### Sentences from *Trouble at Tsavo*

The sun was pushing down on her neck *like a hot iron*. (pg. 18)

Dr. Nimbus turned the wheel hard, ramming the vehicle through a patch of tall dried grass, the shoots *cracking like brittle glass* as the jeep tore through them. (pg. 24)

#### My Word Picture Sentences

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#### My Picture

Draw one of the pictures you have just painted with words.





# GRAY MATTERS

Did you find a direct route from Neuronville to Brain Central? The route involved going up Interstate 101. You have a similar network of highways in your body, with one central "Interstate." The spiderlike tiny roads are the nerves that branch out all over your body. Your spinal cord is a bundle of nerve fibers that acts like the main Interstate Highway.

The spinal cord is the main link between your brain—the body's command center—and the rest of your body. Twelve pairs of nerves connect the brain with muscles and sensory organs in the head (cranial nerves). Thirty-one pairs of nerves connect the brain with muscles and sensory organs in the rest of your body (spinal nerves). Nerves are bundles of tiny **neurons** (NU-rahns), or nerve cells. The entire network is called the **nervous system**.

Amazingly, near the end of your brainstem the neuron highways that lead from the left side of your brain cross over to the right side of your body and the neuron highways from the right side of your brain cross over to the left side of your body! You could say that you are cross-wired!

Just imagine that you are walking across the playground at school and a big, orange basketball suddenly flies toward you. Your friend shouts at you to duck. Your eyes widen. Your heart beats faster. Your muscles go into action as you dodge the oncoming ball. All this happens in a split second. What made this fast reaction possible? The marvelous nervous system!

The nerve highways in your body are the lines of communication. Our five senses take in what



is going on around us and send messages to the brain about what we see, hear, smell, taste, and touch. **Sensory neurons** carry messages from sense organs to the brain. The brain sends messages to your muscles along **motor neurons**. In our example of dodging the basketball, your sensory neurons told your brain, "There is a basketball coming toward me." The brain decided, "I am in danger of getting hit." Your brain sent a message through the motor neurons that told your muscles, "Duck, and get out of the way." A completely different part of your brain started thinking, "Who threw that ball at me?"

**Motor control**, or movement, is one of the important things our bodies can do. Think of how many things you do each day that require your body to move. There are many parts of the brain that help.



## BRAIN FLASH

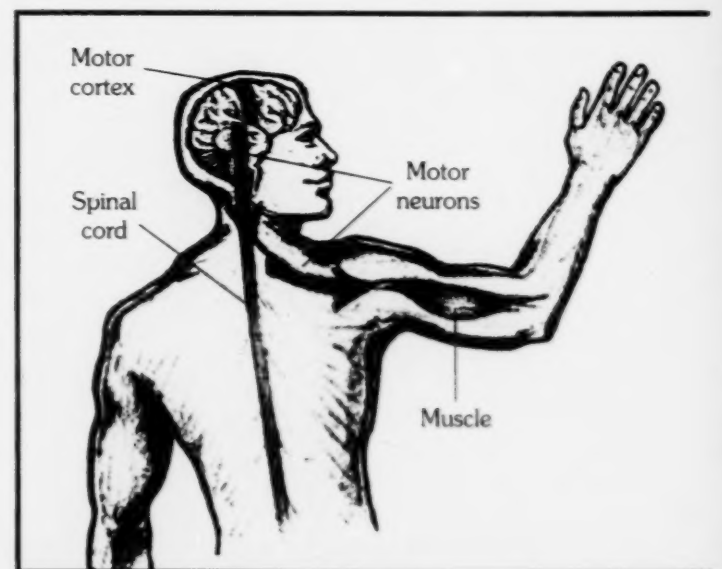
Did you know that a cough or a sneeze is a reflex action? They are ways your body uses to clear things out of your system.

directly from the cerebellum. The cerebellum “knows” how to bike or skate because you have already learned those skills. It knows the “motor programs” for all your familiar actions. You don’t have to think about them.

If you have a baby in your family who is just starting to walk, you can see the marvelous way in which the brain learns about movement. Have you noticed when a baby is just beginning to toddle that, if you distract her, she probably will fall down? That’s because the cerebellum hasn’t taken over walking yet. The motor cortex of the cerebrum is coordinating the movement and the baby has to really “think” about it. As the baby gets more practice, the “walking program” is transferred to the cerebellum. That’s why you can walk and talk at the same time, or sing while you are skating. You don’t have to concentrate hard on telling your muscles what to do. Your cerebellum is doing the work for you.

Remember when you learned how to ride a bicycle or to skate? In the beginning, you fell down a lot. This is because your brain first had to learn how to bike or skate. Next, your brain taught your muscles how to make the correct movements. The part of the brain that “issues orders” to move the muscles is the **motor cortex**. It is located in the cerebrum, just about where you might wear headphones across the top of your head.

When you are first learning a new set of motor skills, you have to concentrate. The motor cortex directs all of the muscle movements with instructions from all over the cerebrum, the “thinking” part of your brain. At the same time, a different part of the brain, the **cerebellum**, is “learning” how the movements are made. After you have learned to ride a bike or to roller skate well, the motor cortex receives instructions







Your spinal cord is made up of millions of neurons (tiny cells that are the building blocks of the nervous system) that allow your brain to communicate with the rest of your body. Each year about 10,000 Americans suffer spinal cord injuries, usually from auto and sports accidents and falls. Often the result is paralysis — not being able to move parts of the body.

Most of the damage to the spinal cord doesn't happen right at the time of an accident, but sometime later. The tissue around the spinal cord begins to bleed and swell. Since this can cause a lot of damage to the neurons in the spinal cord, doctors use special drugs to reduce the bleeding and swelling before too much damage has occurred.

If the neurons in the spinal cord are harmed in an accident, they do not grow back along their original pathways as do neurons in your arms and legs. Scientists are trying to find treatments that get these spinal neurons to grow in the proper direction.

## Use Your Brain — Promote Your Health

Back in the 17th century, Sir Isaac Newton described the laws of motion that still apply today. His laws say that if you are in a car that is traveling 30 miles an hour, you also are moving 30 miles an hour.

When a car hits another object and stops, people in the car keep moving forward, at the same speed the car was traveling, until something — perhaps the steering wheel or windshield — stops them. It is this second collision — the human collision — that often results in injury or death.

Did you realize that car crashes injure and kill more kids than any disease? Crashes also are the leading cause of spinal cord injury. Worn correctly, lap and shoulder belts can save your spinal cord or your life.

Ask your family to help you with this messy experiment.

You will need:  
Two raw eggs  
Masking tape  
A board at least 3 feet long  
Toy car, large enough for your eggs to ride in  
Newspaper

**Important:** Before you begin this experiment, put several sheets of newspaper on the ground and the wall.



- 1) Go outside. Arrange newspapers.
  - 2) Place two raw eggs in a toy car. Use masking tape to make a "safety belt" for one of them.
  - 3) Make a ramp with the board.
  - 4) Wedge one end of the ramp against a wall.
  - 5) Hold up the other end of the ramp.
  - 6) Roll the car down the ramp toward the wall.
- What happens to the eggs?

### Crash Dummy Rap

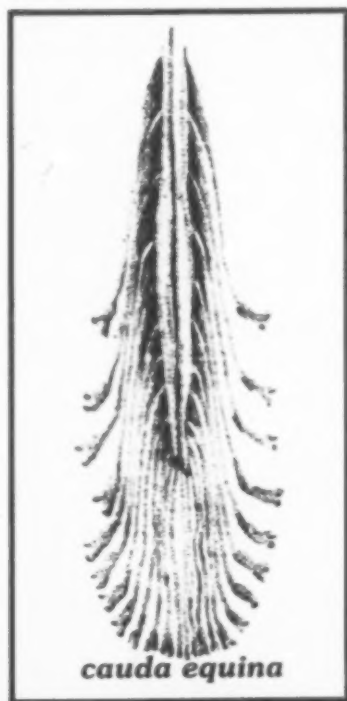
If I ever get the notion  
I can beat the laws of motion,  
I'll think about what Newton might have said...  
*Make the right decision  
and avoid human collision.  
Wear your safety belt, my friend.  
Just use your head!*

# Spinal Cord CRITTER

Have you ever heard of the **cauda equina** (KAW-da ee-KWY-na)? These words are Latin for "Tail of the Horse." Everyone knows what the tail of a horse looks like, but did you know that you have one, and that it is related to your brain?

Hey, we're not just horsing around. Your brain connects to nerves in your body by way of the spinal cord. This cord is a long "bundle" of nerves that runs along the inside of your backbone, or spine.

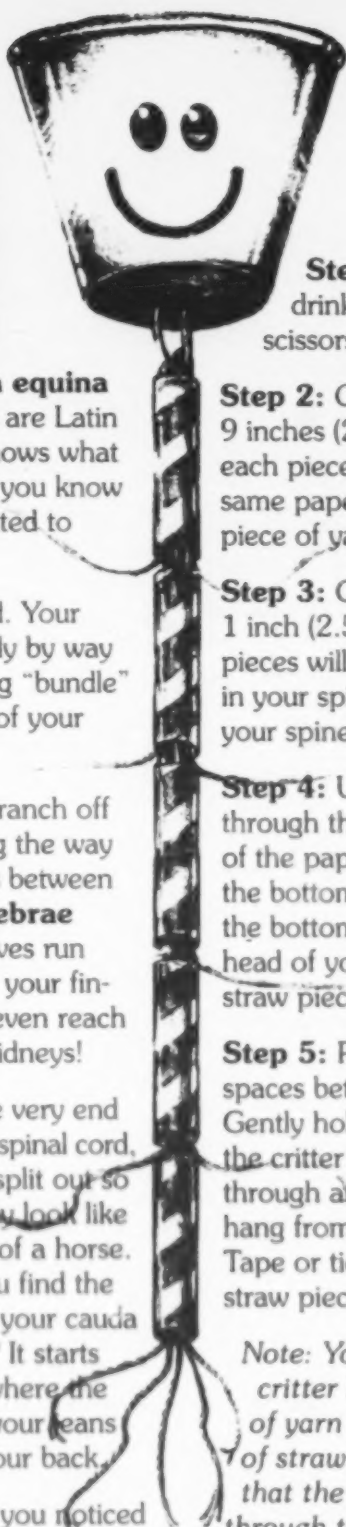
Thirty-one pairs of spinal nerves branch off from the cord at certain points along the way and pass through the narrow spaces between the bones in your spine, called **vertebrae** (VER-tuh-bray). From there, the nerves run throughout your body, to the tips of your fingers, to the tips of your toes. They even reach places like your stomach and your kidneys!



cauda equina

At the very end of your spinal cord, nerves split out so that they look like the tail of a horse. Can you find the area of your cauda equina? It starts about where the top of your jeans cross your back.

Have you noticed that your spine is flexible? If it were one solid bone, what would happen to you? For one thing, you couldn't bend.



## Try This!

**Step 1:** Gather together a plastic drinking straw, yarn, a small paper cup, scissors, tape, and a small paper clip.

**Step 2:** Cut four pieces of yarn, each about 9 inches (23 centimeters) long. Tie one end of each piece of yarn to the smaller end of the same paper clip. Unravel the strands in each piece of yarn.

**Step 3:** Cut five pieces of straw, each about 1 inch (2.5 centimeters) long. These five pieces will represent the groups of vertebrae in your spine. (Actually, there are 33 bones in your spine.)

**Step 4:** Use the paper clip to thread yarn through the five pieces of straw. Poke the end of the paper clip through a hole you make in the bottom of the paper cup. Tape the clip to the bottom of the cup, which represents the head of your critter. (Be careful to keep the straw pieces on the yarn!)

**Step 5:** Pull two strands of yarn through the spaces between each of the straw pieces. Gently hold the bulk of the yarn at the tail of the critter so you don't pull all the yarn through at once. The bunch of strands that hang from the bottom form the cauda equina. Tape or tie the end of your critter to keep the straw pieces from falling off.

*Note: You can make a larger or smaller critter by changing the sizes of the pieces of yarn and straw. Scale the dimensions of straw and yarn accordingly. Be certain that the paper clip can be threaded through the pieces of straw!*

Notice the flexibility of your critter. He has rigid bones (straw) that make up a structure that can bend and move in many directions. Tape your critter onto a piece of paper. Notice how the nerves (yarn) sneak out of the spinal column between vertebrae (straw pieces).

# CAN YOU TEACH A NEW HAND OLD TRICKS?

Which hand do you use to write or draw? The hand that you use for doing most tasks is called the **dominant** hand. By the time you are ten years old, one side of your brain has become dominant. Right-handed people are dominated by the left side of the brain. Which side of the brain is dominant for lefties? Right is right! This cross-wiring happens because the neuron highways switch sides in your brain.

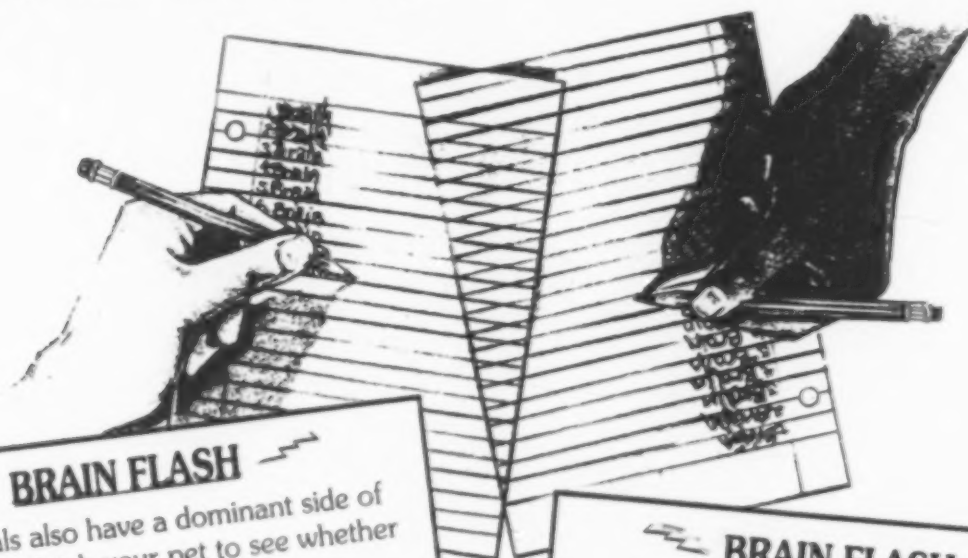
When you write with your dominant hand, you are doing a task that is very well-learned — a skilled movement. Do you remember which part of the brain guides these activities? The **cerebellum** does most of the brain work needed to guide the hand that is writing, so the **cerebrum** is free to do other things — like pay attention to what your teacher is saying in class. When you try to write with your non-dominant hand, you don't have a "motor program" to follow in the cerebellum. Instead, you are using the cerebrum. This is why you have to pay close attention as you learn a new task. Practicing a

task, performing it over and over again, can turn that task into a skilled movement. This can save a lot of thinking time because the "motor program" is transferred to the cerebellum for "automatic pilot."

Now comes the fun part! Here is an experiment you can try with a friend or family member to give you an idea how much effort it takes to get a task transferred from the cerebrum to the cerebellum.

1. Pick a word (like "brain") to practice. Write the word 10 times with your *non-dominant* hand. How legible was the word in your first try compared to your last try?
2. Let your friend do the same thing. Do you both improve?

If you continue to practice, you could learn to write well with both hands. Can you think of other motor activities that were hard at first but that you can do well now?



## BRAIN FLASH

Do animals also have a dominant side of the brain? Watch your pet to see whether it favors one paw over the other.

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## BRAIN FLASH

You also have a dominant eye, foot, and ear. How would you go about checking this out?



Basic Lives

In this episode of **The Far Side**, the man and the animals are shown thinking about things they usually don't have to think about, like walking, "left, right, left..." If we had to "think" about **everything** we did all day, we would really lead "Basic Lives." Thank goodness our cerebellums do these things for us. Our cerebrums are free to think about more complex things like, "How much longer until dinner? I hope we are having ice cream for dessert."

Try doing the activity *Can You Teach a New Hand Old Tricks?* You will be able to experience how hard it would be to have to stop and "think" about simple things like writing your name.

## Careers for Neuro-Explorers: Rehabilitation

When someone receives an injury to his brain or spinal cord, he may be left with a disability like not being able to walk or to use his hands, to speak or to read. Some neuro-explorers in the field of **Physical Medicine and Rehabilitation** help people with diseases and injuries of the nerves, muscles, and joints.

Neuro-Explorer: Charlotte Stelly-Seitz, M.D.  
Pediatric Physiatrist (pee-dee-A-trik fiz-i-A-trist)  
The Institute for Rehabilitation and Research  
Houston, Texas

### **Dr. Stelly-Seitz, what do you do?**

I am the team leader for a group of people who take care of children who are having trouble using or controlling parts of their bodies. With special therapy and equipment, we can help them overcome many of the problems caused by damage to their brains or spinal cords. I work with other specialists, schools and families to take whatever disabilities a child has and find other ways for him or her to do everyday things.

### **What do you find the most fun or most interesting about your work?**

I love the kids' willingness to try something new. They have a spirit to beat the odds — they believe they can do it, even if other people say they can't. And I really enjoy the creativity allowed in my work. The team must find imaginative ways to help each child overcome his or her disability.



### **What advice do you have for future pediatric physiatrists?**

Explore a lot of different things — ask questions and find ways to get the answers. Find people who have enthusiasm to teach you and use them to help you learn. Learn to be a good reader, because then you can always teach yourself.



# Betcha Can't!

Try this with a partner. Get a piece of clear plastic wrap and hold it about 2 inches (5 centimeters) in front of your face. Now have your partner ball-up a piece of notebook paper and throw it softly at your face. Did you blink? Betcha can't keep from blinking! Try it again.

Blinking is a reflex action. There are many kinds of reflex actions, some simple and some more complex. They are automatic and involuntary, which means that they happen without your having to think about them. Most reflexes protect the body from harm. Have you ever touched something hot? Ouch! You jerk your hand away. If you had to think about moving your hand, you would already be badly burned. Only with lots of practice can some reflexes, like blinking, be controlled. How much practice did it take until you kept from blinking? Are you ready to try some other reflex tests?



- You'll need a mirror and a flashlight for testing this *light reflex*. Look in the mirror at your pupil, the round black center of your eye. Next, shine the flashlight toward the pupil and see if you notice any change. Your eye automatically adjusts to let the needed amount of light into your eye. What does your pupil do to adjust to a dark room?

- Do you have a reflex reaction to sound? How might you test this with a friend? Stand behind a friend and clap your hands or pop a balloon when they are not expecting it. They will jump, if you really surprised them. This is called a *startle reflex*. Will they continue to react the same way or get used to the noise if you were to repeat it?

How do reflexes work? When your senses signal a possible danger, the message is carried by sensory neurons into the spinal cord (from the body) or to the brainstem (from the head). From here the message goes in two directions. In less than 1/10 of a second, the message goes back out motor neurons to your muscles to cause movement. The message also goes up to the brain where it is combined with other sensory input and information from memories, so the brain can figure out what just happened and whether any more actions are needed.

## BRAIN FLASH

Another common reflex is putting your arms out to break a fall. You may end up with a broken wrist, but your body knows that it's better than hitting your head. Have you noticed how cats land on their feet when they fall? Animals also have reflex actions.

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